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An Ant Hill in the Congo, converted by Railway Engineers into a Look-out station

ARCHITECTS OF THE ANIMAL KINGDOM.—[See page 229]

The Nature, Origin and Maintenance of Life—II

Inaugural Address of the President of the British Association for the Advancement of Science

By Prof. E. A. Schäfer, LL.D., D.Sc., M.D., F.R.S.

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 1918, page 223, October 5, 1912.

FURTHER COURSE OF EVOLUTION OF LIFE.

ASSUMING the evolution of living matter to have occurred—whether once only or more frequently matters not for the moment—and in the form suggested, viz., as a mass of colloidal slime possessing the property of assimilation and therefore of growth, reproduction would follow as a matter of course. For all material of this physical nature—fluid or semi-fluid in character—has a tendency to undergo subdivision when its bulk exceeds a certain size. The subdivision may be into equal or nearly equal parts, or it may take the form of buds. In either case every separated part would resemble the parent in chemical and physical properties, and would equally possess the property of taking in and assimilating suitable material from its liquid environment, growing in bulk and reproducing its like by subdivision. *Omne vivum e vivo.* In this way from any beginning of living material a primitive form of life would spread, and would gradually people the globe. The establishment of life being once effected, all forms of organization follow under the inevitable laws of evolution. *Ce n'est que le premier pas qui coûte.*

We can trace in imagination the segregation of a more highly phosphorized portion of the primitive living matter, which we may now consider to have become more akin to the protoplasm of organisms with which we are familiar. This more phosphorized portion might not for myriads of generations take the form of a definite nucleus, but it would be composed of material having a composition and qualities similar to those of the nucleus of a cell. Prominent among these qualities is that of catalysis—the function of effecting profound chemical changes in other material in contact with it without itself undergoing permanent change. This catalytic function may have been exercised directly by the living substance or may have been carried on through the agency of the enzymes already mentioned, which are also of a colloid nature, but of simpler constitution than itself, and which differ from the catalytic agents employed by the chemist in the fact that they produce their effects at a relatively low temperature. In the course of evolution special enzymes would become developed for adaptation to special conditions of life, and with the appearance of these and other modifications, a process of differentiation of primitive living matter into individuals with definite specific characters gradually became established. We can conceive of the production in this way from originally undifferentiated living substance of simple differentiated organisms comparable to the lowest forms of Protista. But how long it may have taken to arrive at this stage we have no means of ascertaining. To judge from the evidence afforded by the evolution of higher organisms it would seem that a vast period of time would be necessary for even this amount of organization to establish itself.

FORMATION OF THE NUCLEATED CELL.

The next important phase in the process of evolution would be the segregation and molding of the diffused or irregularly aggregated nuclear matter into a definite nucleus around which all the chemical activity of the organism will in future be centered. Whether this change were due to a slow and gradual process of segregation or of the nature of a jump, such as Nature does occasionally make, the result would be the advancement of the living organism to the condition of a complete nucleated cell: a material advance not only in organization, but—still more important—in potentiality for future development. Life is now embodied in the cell, and every living being evolved from this will itself be either a cell or a cell-aggregate. *Omnis cellula e cellulâ.*

ESTABLISHMENT OF SEXUAL DIFFERENCES.

After the appearance of a nucleus—but how long after it is impossible to conjecture—another phenomenon appeared upon the scene in the occasional exchange of nuclear substance between cells. In this manner became established the process of sexual reproduction. Such exchange in the unicellular Protista might and may occur between any two cells forming the species, but in the multicellular Metazoa it became—like other functions—specialized in particular cells. The result of the exchange is rejuvenescence; associated with an increased tendency to subdivide and to produce new individuals. This is due to the introduction of a stimulating or catalytic chemical agent into the cell which is to be rejuvenated, as is proved by the experiments of Loeb already alluded to. It is true that the chemical material introduced into the germ-cell in the ordinary process of its fertilization by the sperm-cell is usually accompanied by the introduction of definite morphological elements which blend with others already contained within the germ-cell, and it is believed that the transmission of such morphological elements of the parental nuclei is related to the transmission of parental qualities. But we must not be blind to the possibility that these transmitted qualities may be connected with specific chemical characters of the transmitted elements; in other words, that heredity also is one of the questions the eventual solution of which we must look to the chemist to provide.

AGGREGATE LIFE.

So far we have been chiefly considering life as it is found in the simplest forms of living substance, organisms for the most part entirely microscopic and neither distinctively animal nor vegetable, which were grouped together by Haeckel as a separate kingdom of animated nature—that of Protista. But persons unfamiliar with the microscope are not in the habit of associating the term "life" with microscopic organisms, whether these take the form of cells or of minute portions of living substance which have not yet attained to that dignity. We most of us speak and think of life as it occurs in ourselves and other animals with which we are familiar; and as we find it in the plants around us. We recognize it in these by the possession of certain properties—movement, nutrition, growth, and reproduction. We are not aware by intuition, nor can we ascertain without the employment of the microscope, that we and all the higher living beings, whether animal or vegetable, are entirely formed of aggregates of nucleated cells, each microscopic and each possessing its own life. Nor could we suspect by intuition that what we term our life is not a single indivisible property, capable of being blown out with a puff like the flame of a candle; but is the aggregate of the lives of many millions of living cells of which the body is composed. It is but a short while ago that this cell-constitution was discovered; it occurred within the lifetime, even within the memory, of some who are still with us. What a marvelous distance we have traveled since then in the path of knowledge of living organisms! The strides which were made in the advance of the mechanical sciences during the nineteenth century, which is generally considered to mark that century as an age of unexampled progress, are as nothing in comparison with those made in the domain of biology, and their interest is entirely dwarfed by that which is aroused by the facts relating to the phenomena of life which have accumulated within the same period. And not the least remarkable of these facts is the discovery of the cell-structure of plants and animals.

EVOLUTION OF THE CELL-AGGREGATE.

Let us consider how cell-aggregates came to be evolved from organisms consisting of single cells. Two methods are possible, viz. (1) the adhesion of a number of originally separate individuals; (2) the subdivision of a single individual without the products of its subdvision breaking loose from one another. No doubt this last is the manner whereby the cell-aggregate was originally formed, since it is that by which it is still produced, and we know that the life history of the individual is an epitome of that of the species. Such aggregates were in the beginning solid; the cells in contact with one another and even in continuity: subsequently a space or cavity became formed in the interior of the mass, which was thus converted into a hollow sphere. All the cells of the aggregate were at first perfectly similar in structure and in function; there was no subdivision of labor. All would take part in effecting locomotion; all would receive stimuli from outside; all would take in and digest nutrient matter, which would then be passed into the cavity of the sphere to serve as a common store of nourishment. Such organisms are still found, and constitute the lowest types of Metazoa. Later one part of the hollow sphere became dimpled to form a cup; the cavity of the sphere became correspondingly altered in shape. With this change in structure, differentiation of function between the cells covering the outside and those lining the inside of the cup made its appearance. Those on the outside subserved locomotor functions and received and transmitted from cell to cell stimuli, physical or chemical, received by the organism; while those on the inside, being freed from such functions, tended to specialize in the direction of the inception and digestion of nutrient material; which, passing from them into the cavity of the invaginated sphere, served for the nourishment of all the cells composing the organism. The further course of evolution produced many changes of form and ever-increasing complexity of the cavity thus produced by simple invagination. Some of the cell-aggregates settled down to a sedentary life, becoming plant-like in appearance and to some extent in habit. Such organisms, complex in form but simple in structure, are the Sponges. Their several parts are not, as in the higher Metazoa, closely interdependent; the destruction of any one part, however extensive, does not either immediately or ultimately involve death of the rest; all parts function separately, although doubtless mutually benefitting by their conjunction, if only by slow diffusion of nutrient fluid throughout the mass. There is already some differentiation in these organisms, but the absence of a nervous system prevents any general co-ordination, and the individual cells are largely independent of one another.

Our own life, like that of all the higher animals, is an *aggregate life;* the life of the whole is the life of the individual cells. The life of some of these cells can be put an end to, the rest may continue to live. This is, in fact, happening every moment of our lives. The cells which cover the surface of our body, which form the scarf-skin and the hairs and nails, are constantly dying and the dead cells are rubbed off or cut away, their place being taken by others supplied from living layers beneath. But the death of these cells does not affect the vitality of the body as a whole. They serve merely as a protection, or an ornamental covering, but are otherwise not material to our existence. On the other hand, if a few cells, such as those nerve-cells under the influence of which respiration is carried on, are destroyed or injured, within a minute or two the whole living machine comes to a standstill, so that to the bystander the patient is dead; even the doctor will pronounce life to be extinct. But this pronouncement is correct only in a special sense. What has happened is that, owing to the cessation of respiration, the supply of oxygen to the tissues is cut off. And since the manifestations of life cease without this supply, the animal or patient appears to be dead. If, however, within a short period we supply the needed oxygen to the tissues requiring it, all the manifestations of life reappear.

It is only some cells which lose their vitality at the moment of so-called "general death." Many cells of the body retain their individual life in suitable circumstances long after the rest of the body is dead. Notable among these are muscle-cells. McWilliam showed that the muscle-cells of the blood vessels give indications of life several days after an animal has been killed. The muscle-cells of the heart in mammals have been revived and caused to beat regularly and strongly many hours after apparent death. In man this result has been obtained by Kuliabko as many as eighteen hours after life had been pronounced extinct; in animals after days had elapsed. Waller has shown that indications of life can be elicited from various tissues many hours and even days after general death. Sherrington observed the white corpuscles of the blood to be active when kept in a suitable nutrient fluid weeks after removal from the blood vessels. A French histologist, Jolly, has found that the white corpuscles of the frog, if kept in a cool place and under suitable conditions, show at the end of a year all the ordinary manifestations of life. Carrell and Burrows have observed activity and growth to continue for long periods in the isolated cells of a number of tissues and organs kept under observation in a suitable medium. Carrell has succeeded in substituting entire organs obtained after death from one animal for those of another of the same species, and has thereby opened up a field of surgical treatment the limit of which cannot yet be described. It is a well-established fact that any part of the body can be maintained alive for hours isolated from the rest if the blood vessels are perfused with an oxygenated solution of salts in certain proportions (Ringer). Such revival and prolongation of the life of separated organs is an ordinary procedure in

laboratories of physiology. Like all the other instances enumerated, it is based on the fact that the individual cells of an organ have a life of their own which is largely independent, so that they will continue in suitable circumstances to live, although the rest of the body to which they belonged may be dead.

But some cells, and the organs which are formed of them, are more necessary to maintain the life of the aggregate than others, on account of the nature of the functions which have become specialized in them. This is the case with the nerve cells of the respiratory center, since they preside over the movements which are necessary to effect oxygenation of the blood. It is also true for the cells which compose the heart, since this serves to pump oxygenated blood to all other cells of the body; without such blood most cells soon cease to live. Hence we examine respiration and heart to determine if life is present; when one or both of these are at a standstill we know that life cannot be maintained. These are not the only organs necessary for the maintenance of life, but the loss of others can be borne longer, since the functions which they subserve, although useful or even essential to the organism, can be dispensed with for a time. The life of some cells is therefore more, of others less, necessary, for maintaining the life of the rest. On the other hand, the cells composing certain organs have in the course of evolution ceased to be necessary, and their continued existence may even be harmful. Wiedersheim has enumerated more than a hundred of these organs in the human body. Doubtless Nature is doing her best to get rid of them for us, and our descendants will some day have ceased to possess a vermiform appendix or a pharyngeal tonsil; until that epoch arrives we must rely for their removal on the more rapid methods of surgery!

THE MAINTENANCE OF THE LIFE OF THE CELL-AGGREGATE IN THE HIGHER ANIMAL.—CO-ORDINATING MECHANISM.

We have seen that in the simplest multicellular organisms, where one cell of the aggregate differs but little from another, the conditions for the maintenance of the life of the whole are nearly as simple as those for individual cells. But the life of a cell-aggregate such as composes the bodies of the higher animals is maintained not only by the conditions for the maintenance of the life of the individual cell being kept favorable, but also by the co-ordination of the varied activities of the cells which form the aggregate. Whereas in the lowest Metazoa all cells of the aggregate are alike in structure and function and perform and share everything in common, in higher animals (and for that matter in the higher plants also) the cells have become specialized, and each is only adapted for the performance of a particular function. Thus the cells of the gastric glands are only adapted for the secretion of gastric juice, the cells of the villi for the absorption of digested matters from the intestine, the cells of the kidney for the removal of waste products and superfluous water from the blood, those of the heart for pumping blood through the vessels. Each of these cells has its individual life and performs its individual functions. But unless there were some sort of co-operation and subordination to the needs of the body generally, there would be sometimes too little, sometimes too much gastric juice secreted; sometimes too tardy, sometimes too rapid an absorption from the intestine; sometimes too little, sometimes too much blood pumped into the arteries, and so on. As the result of such lack of co-operation the life of the whole would cease to be normal and would eventually cease.

We have already seen what are the conditions which are favorable for the maintenance of life of the individual cell, no matter where situated. The principal condition is that it must be bathed by a nutrient fluid of suitable and constant composition. In higher animals this fluid is lymph, which bathes the tissue elements and is itself constantly supplied with fresh nutriment and oxygen by the blood. Some tissue cells are directly bathed by blood; and in invertebrates, in which there is not special system of lymph vessels, all the tissues are thus nourished. All cells both take from and give to the blood, but not the same materials or to an equal extent. Some, such as the absorbing cells of the villi, almost exclusively give; others, such as the cells of the renal tubules, almost exclusively take. Nevertheless, the resultant of all the give and take throughout the body serves to maintain the composition of the blood constant in all circumstances. In this way the first condition of the maintenance of the life of the aggregate is fulfilled by insuring that the life of the individual cells composing it is kept normal.

The second essential condition for the maintenance of life of the cell-aggregate is the co-ordination of its parts and the due regulation of their activity, so that they may work together for the benefit of the whole. In the animal body this is effected in two ways: first, through the nervous system; and second, by the action of specific chemical substances which are formed in certain organs and carried by the blood to other parts of the body, the cells of which they excite to activity. These substances have received the general designation of "hormones" (*ορμάω*, to stir up), a term introduced by Prof. Starling. Their action, and indeed their very existence, has only been recognized of late years, although the part which they play in the physiology of animals appears to be only second in importance to that of the nervous system itself; indeed, maintenance of life may become impossible in the absence of certain of these hormones.

PART PLAYED BY THE NERVOUS SYSTEM IN THE MAINTENANCE OF AGGREGATE LIFE.—EVOLUTION OF A NERVOUS SYSTEM.

Before we consider the manner in which the nervous system serves to co-ordinate the life of the cell-aggregate, let us see how it has become evolved.

The first step in the process was taken when certain of the cells of the external layer became specially sensitive to stimuli from outside, whether caused by mechanical impressions (tactile and auditory stimuli) or impressions of light and darkness (visual stimuli) or chemical impressions. The effects of such impressions were probably at first simply communicated to adjacent cells and spread from cell to cell throughout the mass. An advance was made when the more impressionable cells threw out branching feelers among the other cells of the organism. Such feelers would convey the effects of stimuli with greater rapidity and directness to distant parts. They may at first have been retractile, in this respect resembling the long pseudopodia of certain Rhizopoda. When they became fixed they would be potential nerve fibers and would represent the beginning of a nervous system. Even yet (as Ross Harrison has shown), in the course of development of nerve fibers, each fiber makes its appearance as an amœboid cell process which is at first retractile, but gradually grows into the position it is eventually to occupy.

In the further course of evolution a certain number of these specialized cells of the external layer sank below the general surface, partly perhaps for protection, partly for better nutrition; they became nerve cells. They remained connected with the surface by a prolongation which became an afferent or sensory nerve fiber, and through its termination between the cells of the general surface continued to receive the effects of external impressions; on the other hand, they continued to transmit these impressions to other more distant cells by their efferent prolongations. In the further course of evolution the nervous system thus laid down became differentiated into distinct *afferent*, *efferent*, and *intermediary* portions. Once established, such a nervous system, however simple, must dominate the organism, since it would furnish a mechanism whereby the individual cells would work together more effectually for the benefit of the whole.

It is the development of the nervous system, although not proceeding in all classes along exactly the same lines, which is the most prominent feature of the evolution of the Metazoa. By and through it all impressions reaching the organism from the outside are translated into contraction or some other form of cell activity. Its formation has been the means of causing the complete divergence of the world of animals from the world of plants, none of which possess any trace of a nervous system. Plants react, it is true, to external impressions, and these impressions produce profound changes and even comparatively rapid and energetic movements in parts distant from the point of application of the stimulus—as in the well-known instance of the sensitive plant. But the impressions are in all cases propagated directly from cell to cell—not through the agency of nerve fibers—and in the absence of anything corresponding to a nervous system it is not possible to suppose that any plant can ever acquire the least glimmer of intelligence. In animals, on the other hand, from a slight original modification of certain cells has directly proceeded in the course of evolution the elaborate structure of the nervous system with all its varied and complex functions, which reach their culmination in the workings of the human intellect. "What a piece of work is a man! How noble in reason! How infinite in faculty! In form and moving how express and admirable! In action how like an angel! In apprehension how like a god!" But lest he be elated with his physical achievements, let him remember that they are but the result of the acquisition by a few cells in a remote ancestor of a slightly greater tendency to react to an external stimulus, so that these cells were brought into closer touch with the outer world; while, on the other hand, by extending beyond the circumscribed area to which their neighbors remained restricted, they gradually acquired a dominating influence over the rest. These dominating cells became nerve cells; and now not only furnish the means for transmission of impressions from one part of the organism to another, but in the progress of time have become the seat of perception and conscious sensation, of the formation and association of ideas, of memory, volition, and all the manifestations of the mind!

REGULATION OF MOVEMENT BY THE NERVOUS SYSTEM.—VOLUNTARY MOVEMENTS.

The most conspicuous part played by the nervous system in the phenomena of life is that which produces and regulates the general movements of the body—movements brought about by the so-called voluntary muscles. These movements are actually the result of impressions imparted to sensory or afferent nerves at the periphery, e. g., in the skin or in the several organs of special sense; the effect of these impressions may not be immediate, but can be stored for an indefinite time in certain cells of the nervous system. The regulation of movements—whether they occur instantly after reception of the peripheral impression or result after a certain lapse of time; whether they are accompanied by conscious sensation or are of a purely reflex and unconscious character—is an intricate process, and the conditions of their co-ordination are of a complex nature involving not merely the causation of contraction of certain muscles, but also the prevention of contraction of others. For our present knowledge of these conditions we are largely indebted to the researches of Prof. Sherrington.

INVOLUNTARY MOVEMENTS.

A less conspicuous but no less important part played by the nervous system is that by which the contractions of involuntary muscles are regulated. In normal circumstances these are always independent of consciousness, but their regulation is brought about in much the same way as is that of the contractions of voluntary muscles, viz., as the result of impressions received at the periphery. These are transmitted by afferent fibers to the central nervous system, and from the later other impulses are sent down, mostly along the nerves of the sympathetic or autonomic system of nerves, which either stimulate or prevent contraction of the involuntary muscles. Many involuntary muscles have a natural tendency to continuous or rhythmic contraction which is quite independent of the central nervous system; in this case the effect of impulses received from the latter is merely to increase or diminish the amount of such contraction. An example of this double effect is observed in connection with the heart, which—although it can contract regularly and rhythmically when cut off from the nervous system and even if removed from the body—is normally stimulated to increased activity by impulses coming from the central nervous system through the sympathetic, or to diminished activity by others coming through the vagus. It is due to the readiness by which the action of the heart is influenced in these opposite ways by the spread of impulses generated during the nerve storms which we term "emotions" that in the language of poetry, and even of every day, the word "heart" has become synonymous with the emotions themselves.

EFFECTS OF EMOTIONS.

The involuntary muscle of the arteries has its action similarly balanced. When its contraction is increased the size of the vessels is lessened and they deliver less blood; the parts they supply accordingly become pale in color. On the other hand, when the contraction is diminished the vessels enlarge and deliver more blood; the parts which they supply become correspondingly ruddy. These changes in the arteries, like the effects upon the heart, may also be produced under the influence of emotions. Thus "blushing" is a purely physiological phenomenon due to diminished action of the muscular tissue of the arteries, while the pallor produced by fright is caused by an increased contraction of that tissue. Apart, however, from these conspicuous effects, there is constantly proceeding a less apparent but not less important balancing action between the two sets of nerve fibers distributed to heart and blood vessels; which are influenced in one direction or another by every sensation which we experience and even by impressions of which we may be wholly unconscious, such as those which occur during sleep or anæsthesia, or which affect our otherwise insensitive internal organs.

REGULATION OF SECRETION BY THE NERVOUS SYSTEM.

A further instance of nerve regulation is seen in secreting glands. Not all glands are thus regulated, at least not directly; but in those which are the effects are striking. Their regulation is of the same general nature as that exercised upon involuntary muscle, but it influences the chemical activities of the gland cells and the outpouring of secretion from them. By means of this regulation a secretion can be produced or arrested, increased or diminished. As with muscle, a suitable balance is in this way maintained, and the activity of the glands is adapted to the requirements of the organism. Most of the digestive glands are thus influenced, as are the sweat glands of the skin.

(To be continued.)

Henry Bell and the "Comet"

The Centenary of the First Passenger Steamboat in Europe

Three years ago we were celebrating the hundredth anniversary of the successful inauguration of practical commercial steamboat navigation on the Hudson River. The present year marks a similar occasion for our British cousins. We reproduce below a special article published in a recent issue of the Illustrated London News in commemoration of the event.

Patrick Miller, Financier of the Early Days of Steamship Service.

Henry Bell, Founder of Passenger Steamboat Service on the Clyde.

Of the many anniversaries of important events in the history of the British Nation which have called for celebration this year, or still call for it, none is of greater interest than that of August 6th. On that day, one hundred years ago, the steamboat "Comet" made her first trip on the river Clyde and heralded an epoch in the progress of civilization, as well as a great triumph for man in his persistent fight against the elements. This tiny germ was the precursor of the floating palaces of the present day and the mercantile and naval service of the world.

The idea of steam navigation dates as far back as the year 1543, when a Spanish captain named Blasco de Garay experimented in Barcelona Harbor with a steamboat of his own invention. This vessel, which was of 200 tons burden, attained a speed of three miles per hour. In 1736 various trials were made on the Severn; and in the later half of that century both Frenchmen and Americans were engaged in attempts to solve the problem of steam navigation.

In 1788 William Symington, a native of Leadhills, Lanarkshire, achieved success by propelling a double-keeled vessel on Dalswinton Loch, Dumfriesshire, and in 1789 he fitted out a larger boat with engines, which was propelled at a speed of six miles per hour on the Forth and Clyde Canal. His "Charlotte Dundas," a stern-wheeler, built at Grangemouth in 1801, made an experimental trip to Glasgow, and was intended for towing sloops on the Forth and Clyde Canal, but was withdrawn owing to the damage caused to the banks through the wash of the paddles. It was on this vessel that Fulton, the American engineer, who introduced steam navigation upon the Hudson River, was, on one occasion, a passenger, and made the acquaintance of Symington. In 1803 another attempt was made by Symington with his second "Charlotte Dundas," but the director of the Forth and Clyde Canal, with a lack of foresight, and being apprehensive of their banks, ordered this boat to cease operations. Symington's experiments, so far fairly successful, had involved him in financial difficulties. He died in London in 1831, and was buried in the churchyard of St. Botolph, Aldgate.

Something of the perverse fate which dogged the efforts of Symington to convince his contemporaries of the great method of navigation attended the work of Henry Bell. Bell, however, has the distinction of producing the first practical steamboat to ply regularly on European waters. He was born at Linlithgow on April 7th, 1767, and was first employed as a stonemason. Three years at that trade proved enough for him, and he subsequently served an apprenticeship as a mechanic.

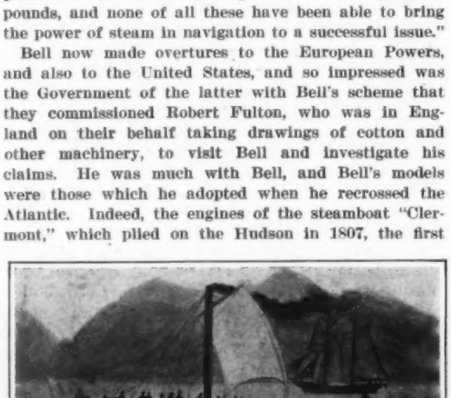
During the time Symington was experimenting on Dalswinton Loch and the Forth and Clyde Canal, Bell was studying the possibilities of steam for the propulsion of ships. As early as 1800, a year before the appearance of the first "Charlotte Dundas," Bell had applied to the Lords of the Admiralty for leave to demonstrate to them the practicability and utility of an invention whereby vessels might be driven against wind and tide. The Lords of the Admiralty came to the conclusion that his scheme was unworkable, and could not give him their support. Lord Nelson, however, was a warm supporter of Bell's plans, and saw with a clear eye the vast possibilities of the enterprise. It is recorded that he threw out a serious warning to their Lordships in the following famous words:

"My Lords and Gentlemen.—If you do not adopt Mr. Bell's scheme, other nations will, and in the end vex every vein in the Empire. It will succeed, and you should encourage Mr. Bell."

Bell was, fortunately, endowed with a plentiful stock of confidence in the utility of his scheme, and was not discouraged by a short-sighted government. He experimented with a pleasure boat, into which he placed a boiler and engine of four horse-power. Subsequently, he sought the advice of James Watt as to a portable engine that would stand on its own base, with strong lever, of which he suggested the design. Watt's reply was discouraging. He wrote thus:

"How many noblemen, gentlemen, and engineers have puzzled their brains and spent their thousands of pounds, and none of all these have been able to bring the power of steam in navigation to a successful issue."

Bell now made overtures to the European Powers, and also to the United States, and so impressed was the Government of the latter with Bell's scheme that they commissioned Robert Fulton, who was in England on their behalf taking drawings of cotton and other machinery, to visit Bell and investigate his claims. He was much with Bell, and Bell's models were those which he adopted when he recrossed the Atlantic. Indeed, the engines of the steamboat "Clermont," which plied on the Hudson in 1807, the first



The Steamship "Comet," Built by Henry Bell in 1811.

American vessel to be propelled by steam, were built, on Bell's suggestion, at the works of Messrs. Bolton and Watt, Birmingham.

On the dispute as to who has the honor of inventing the steamship, the report of the Select Committee of the House of Commons on Steamboats, published in 1822, sums up the various claims to that distinction. It states:

"Mr. Jonathan Hulls, in 1736; the Duke of Bridgewater, on the Manchester and Runcorn Canal; Mr. Miller, of Dalswinton; the Marquis of Jouffroy, a French nobleman, in 1781; Lord Stanhope, in 1795; and Messrs. Symington and Taylor, on the Forth and Clyde Canal, in 1801-02: these ingenious men made valuable experiments and tested well the mighty power of steam. Still no practical uses resulted from any of these attempts. It was not till the year 1807, when the Americans began to use steamboats on their rivers, that their safety and utility was first proved. But the merit of constructing these boats is due to the natives of Great Britain. Mr. Henry Bell, of Glasgow, gave the first model of them to the late Mr. Fulton, of America, and corresponded regularly with Fulton on the subject. Mr. Bell continued to turn his talents to the improving of steam apparatus and its application to various manufactures around about Glasgow; and, in 1811, constructed the "Comet" steamboat (the first of its kind in Europe) to navigate the Clyde from Glasgow to Port Glasgow, Greenock, and Inverness."

About 1807, Bell had a definite conception of the style of engines he desired for propelling a vessel. A year or two later he was in communication with the brothers John and Charles Wood, shipbuilders, Port Glasgow, and eventually commissioned John Wood to build a vessel for him at his yard, Port Glasgow. The engines were made by John Robertson, engineer, Glasgow, and the boiler by David Napier.

The date of the launch, on the authority of a list supplied by the builders, and contained in a Parliamentary report of 1822, is July 24th, 1812. The vessel was launched practically complete with steam up, and was named the "Comet," after a meteor which appeared in the heavens some time previously. Built of wood, she was 43 feet 6 inches long; 11 feet 4 inches broad; 5 feet 9 inches deep, with a draught of 4 feet. She carried a large square sail, which was brought into use when the weather was favorable. The engine was of the condensing type of three horse-power, the cylinder 11½ inches diameter, and the stroke 16 inches. She was originally fitted with two pairs of paddle-wheels, 7 feet in diameter. The preliminary trials of the vessel proved a failure owing to one pair of paddle-wheels working in the wash of the other, and causing a loss of power. One pair of the paddles was removed, and another engine of four horse-power substituted, having a cylinder of 12½ inches.

The "Comet's" first voyage was from Greenock to Glasgow, on August 6th, 1812, the distance of twenty-two miles being covered in 3½ hours. After plying on the Clyde for a month, her sailings were extended, as we find that she sailed through the Kyles of Bute to Tarbert, Loch Fyne, thence through the Crinan Canal to Oban and Fort William, the return journey occupying four days. The "Comet" was, therefore, the first steamer to use the Crinan Canal. After a short time on this route she was transferred to Grangemouth, but in August, 1819, she reappeared on the West Coast and resumed her West Highland voyages.

On December 19th, 1820, the "Comet," on a voyage from Oban to Glasgow, was wrecked outside Crinan, the crew and passengers fortunately being able to scramble ashore. When the "Comet" was wrecked, Bell was on board, and on his way to Glasgow to arrange for the building of a larger vessel; and in 1821 the second "Comet" was built by James Lang, of Dumbarton.

Bell derived no benefit from his first venture, and the loss of the second "Comet" brought him financial disaster. He was never in a position to pay in full either the builder or the maker of the engine of the first "Comet," but, with great generosity, Wood did not press for a settlement.

Henry Bell died at Helensburgh on November 14th, 1830, having lived for eighteen years after the birth of his famous "Comet," to see the evolution of the result of his genius perseverance.

The African Ant

Architects of the Animal Kingdom

Of the African ant, the best known species is the white ant or termite. Then we have the driver ant, and also the red ant, the tree ant, and the lion ant. Although the majority of them are regarded as pests of men, they, nevertheless, fulfil a useful purpose in nature, acting as sextons and sanitary inspectors, checking the spread of disease in the animal and vegetable kingdoms, and adding enormously to the improvement of the soil.

Strictly speaking, the white ants or termites are not true ants, although they resemble them in appearance and in their general mode of life. They belong to the order Neuroptera, and are thus allied to the dragon-flies, may-flies, grasshoppers, etc., whereas the real ants belong to the order Hymenoptera, in which bees and wasps are included. The abdomen in the white ant is not joined to the body by one or two knots, as in the ants proper. Their mouth has an upper and lower lip and two strong mandibles. Their wings are very long and narrow. They have no sting.

In the matter of nests these white or false ants excel all the true species, and in fact all other insects. These nests are built above, instead of below, the ground, and attain such a size and rise to such a height, that they form a marked feature of the landscape, and may almost be said to turn a flat country into a hilly one. They rise from 20 to 60 feet in height, while the base of the structure varies from 100 to 200 yards in circumference. They are very solid and frequently antelopes and even buffaloes may be seen grazing upon them. Again, one often detects bamboo trees growing upon them, while their sides are often covered with the choicest of tropical ferns, delicate orchids and other rare plants. They are invariably found in groups, as many as twenty nests or more covering a comparatively small area.

When the builders of the Cape to Cairo Railroad reached the Congo they entered a region where these creatures abound and hundreds of ant heaps had to be demolished to make way for the iron road. The rapidity with which these ants worked was a revelation to many of the engineers. They would clear a track in the forest and when they returned three or four days later were surprised to find that the ants had reared one of their structures in the center of their path. Near Broken Hill a number of ant heaps were partially cut down to allow the train to pass. About a week or so later the driver experienced great difficulty in getting by because the ants, in endeavoring to repair the damage done to their homes had built outwards huge carbuncles which projected out over the track. They were so solidly bound to the main heap that they had to be removed with pickaxes.

The nest of the white ant is really a wonderful structure, built of earth, stones and wood, glued together by saliva, the whole being protected by a thick layer of clay. It forms an ideal cement, and is used by the settlers and natives in the erection of their houses. The nest is so constructed that all rain is immediately carried off. The whole mound is dotted with little holes which are the orifices to so many passages, leading into the interior, while the interior itself presents the most wonderful arrangement of galleries, halls, nurseries, and so forth, that exist in the insect world. In the middle of the nest is the palace of the king and queen. The queen spends all her time in laying eggs. As the eggs are laid they are carried off to the nurseries by the attendant workers. The nurseries for eggs and larvæ are built around the palace. There are cells, too, for the royal bodyguard, and for the royal servants. Besides these there are storerooms filled with such supplies as gums and resins; with meal, seeds, dried plant juice, fruits and wood pulp.

These ants are very destructive, destroying everything except iron and steel. Railroad engineers know this, with the result that when they enter a region where these creatures exist they have to either use steel or cover wooden structures with sheet iron. The ants bore into any solid substance, and eat out its interior, leaving it hollow, with its outer surface represented by a thin shell, intact. The rapidity with which they work is remarkable, and in a single night they have been known to burrow all through the leg of a table, then across the table, stopping on the way to devour the articles lying upon it, and down through another leg into the floor again. The wooden pillars that support the roof of a dwelling, the woodwork of the roof itself, may be destroyed by these insects before the inhabitants are even aware of their presence.

The termites have many enemies, but only one that assaults them in their fortress, namely, the ant-bear, an uncouth, naked-looking animal about the size of a pig, with tremendous claws, great, muscular bowed fore-legs, a proboscis-looking snout, and long narrow ears like a donkey. It is perfectly harmless, but in a single night will wreck an ant heap. There is no animal, it is said, that can burrow so quickly as the ant-bear. In a few minutes this creature will burrow its way into an ant-heap and then by shooting out its worm-like, sticky tongue collect the ants by the hundred and swallow them.

A Typical Termite Nest in South Africa.

Another species is the driver ant, which is black, and attains a length of about half an inch to three-quarters of an inch. They go about in huge droves and if by any chance a mouse or an elephant stands in their road it is forced to speedily move on or remain and be eaten up. They only make their appearance in the rainy season and then, in certain parts of Africa, it is a common occurrence to see long lines of these ants on the march. They rapidly advance in perfect formation, in lines two to three feet wide, and often extending for nearly half a mile with an organization and military precision that is truly marvelous. It is interesting to watch them pass. First comes a column in close formation, consisting of warrior ants possessing formidable-looking nippers, led by one or more very large ants, twice the size of the others. Behind them follows a mixed mass of smaller ants. These are the carriers, carrying various loads; some bring eggs, others their young, bits of leaves and sticks, grass, berries and dead bodies of insects. Their sagacity and engineering aptitude are truly remarkable, as seen by the wonderful tunnels they construct, generally under the exposed portion of the road on their line of march, where there is any danger of a torrent washing down through a sudden downpour of rain.

As already stated, these creatures will destroy and eat any animal that lies in their path. At Pemba Station, in North West Rhodesia, Mr. Ayton, the station master, had a pet monkey chained to a pole with a little house on top. One night a drove of driver ants came along and next morning only the white bones of the monkey were to be seen. He had been eaten by the ants, being unable to get away because of the chain. One of the engineers on the Cape to Cairo Railroad told me also of incidents where these creatures had entered their fowl houses and destroyed the poultry. When these ants enter negro villages the inhabitants at once decamp and wait until they have passed. These intrusions, however, are attended with certain benefits. The appearance of these ants in a house is soon revealed by the simultaneous movement of all the rats, mice, lizards, cockroaches and other vermin which swarm in the dwellings in warm countries, and these are either compelled to decamp hastily, or are caught, killed and devoured.

The red ant is quite a small creature, making its nest in the ground, under stones, in the stumps of trees, etc., and is to be found in large numbers. There are, of course, a host of other ants on the African continent, but those described are by far the most interesting of this wonderful and strange form of insect life.

Among the enemies of the ant should be mentioned the ant-lion that resorts to an ingenious method in securing its prey. It burrows a pit in the sand, shaped like the mouth of a funnel, being wide at the top and becoming gradually narrower toward the bottom. Buried in the center at the bottom, with only its mandibles projecting, the ant-lion waits until an ant or some other insect falls down the loose sides of the pit, when it is immediately seized with the pincer-like jaws, and retained until all the juices of its body have been sucked out, and nothing left but the dry and shriveled skin. The latter is cast outside the pit, and the ant-lion again lies in wait for the next victim.

Electrolysis from Stray Currents—IV*

Damage Caused to Underground Structures

By Albert F. Ganz, M. E., Professor of Electrical Engineering, Stevens Institute of Technology

Concluded from Scientific American Supplement No. 1918, Page 219, October 5, 1912

A convenient form of insulating joint for small wrought iron or steel pipes is the Macallan joint which is illustrated in Fig. 13. This is very largely used for insulating water and gas-service pipes. A convenient form of insulating joint for large pipes is illustrated in Fig. 14, where a flanged joint is shown with a fiber disk between the surfaces of the flanges, and with the bolts insulated with fiber tubing and the bolt heads and nuts insulated with fiber washers. This form of flanged insulating joint has been very largely used for water and for gas mains. The Dresser insulating joints are also very satisfactory. Insulating joints can often be used to great advantage in special cases, as for example in the case illustrated in Fig. 11, where an insulating joint in the gas service inside of the building would protect the gas service pipe, by preventing the current from flowing out of the building on this pipe. Insulating joints on mains must, however, be used with very great caution, as they can under unfavorable conditions do more harm than good. It is sometimes possible to use comparatively few insulating joints to break up the electrical continuity of a pipe line, and protect the pipe line from electrolysis, but such joints must be installed only after careful tests have shown that the current is not likely to shunt through ground around them. This depends largely upon the potential gradient through ground and upon the electrical resistance of the ground in the territory considered.

While relief from serious electrolysis can at times be obtained by such special measures as insulating pipe coverings or insulating joints, it must be understood that all remedial measures should have for their first aim the reduction of the drop in potential in the rails to a minimum, because this removes the cause of the trouble. The first and most important step necessary to accomplish this is to maintain the rails perfectly bonded, so that the tracks themselves form continuous electrical conductors. The next important step is to limit the radius from the power station to which the station supplies electric power, so that current does not have to be returned from excessive lengths of rail lines to any one power station. This is

*A lecture delivered before the American Water Works Association at Louisville, Ky., June 6th, 1912.

usually accomplished in practice by supplying power to electric railways from distributed sub-stations. The next step is to remove the current from the rails wherever there is concentration of current, by means of insulated return feeders connecting from the rails at these points

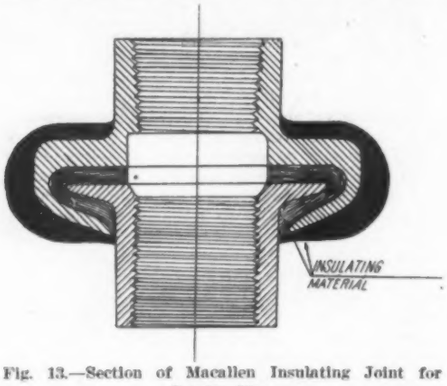


Fig. 13.—Section of Macallen Insulating Joint for Service Pipe.

to the power station. In order that such insulated return feeders should be most efficient in reducing drop in potential in grounded rails, these feeders should be proportioned for constant drop, so that the rails at all points where return feeders are connected are maintained at substantially the same potential under average load conditions. This also requires that the rails immediately in front of the power station must not be connected directly to the negative bus-bar, unless a resistance corresponding to the average resistance of the return feeders is connected in the circuit. Where it is necessary to bring current back from a distant point in the rails, it is sometimes more economical to employ a negative booster in series with this return feeder rather than make this feeder of such large cross-section as would be required to maintain the distant point in the rails at the same potential as the nearer connection points. With this system part of the voltage drop is actually removed from the rails and transferred to the insulated return feeders from which current cannot leak to ground.

great reduction of stray currents can be accomplished by insulating the negative bus-bar at the power station from ground connections and from rails, and returning the current by means of insulated return feeders.

Since power stations are usually located near the center of load of an electric railway system, it is usual in cities to find railway lines radiating out from the power

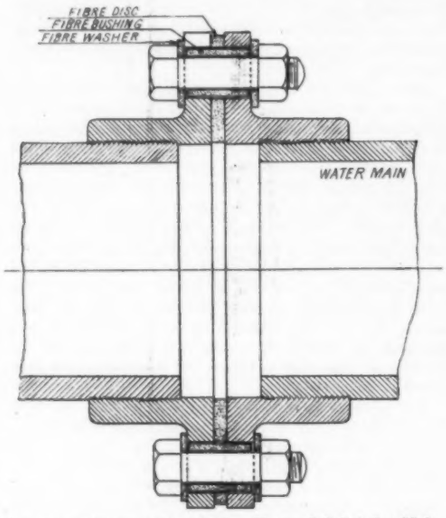


Fig. 14.—Section of Insulating Flanged Joint for Main.

station. Where the running tracks are connected to the negative bus-bar only in the immediate neighborhood of the power station, these running tracks are depended upon alone to return current to the power station, and there is consequently always very great concentration of stray current under these circumstances in the neighborhood of the power station. Such railway lines radiating out from the power station are illustrated diagrammatically in Fig. 17. In this figure eight railway lines are assumed radiating out from the power station. In the left-hand diagram of Fig. 17 the rails of these lines are

ground and on the underground piping in the neighborhood of the railway power station, where they must return to the rails to get back to the negative bus-bar.

If this connection between the negative bus-bar and the rails at the power station were removed, and the currents returned from the rails at points near the center of each railway line by means of insulated return feeders, as shown in the upper diagram of Fig. 17, this concentration of current in the neighborhood of the power station would be entirely removed. With this arrangement, the current used by each individual line would tend to flow away from the rails at points away from the center of each line, and toward the rails near the center of each line. It is, therefore, seen that there is only ⅛ of the current returning from the rails at any one point than there is when the rails are connected to the negative bus-bar only at the power station. Further, the total stray current through ground with the conditions shown in the upper diagram will be only ¼ of the total stray current with the conditions of the lower diagram, assuming similar soil conditions, so that at any one point the danger from electrolysis will be 1/32 of what it is in the neighborhood of the power station with the first arrangement. As a matter of practice, however, the actual reduction is very much greater, because the return feeder connection points on the rails can be chosen so as to be located where the ground is high and dry, and consequently of high resistance, while the railway power station is generally located near water, where the ground

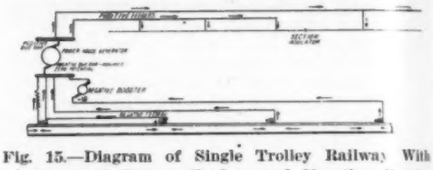


Fig. 15.—Diagram of Single Trolley Railway With Insulated Return Feeders and Negative Booster Showing Path of Currents and Assumed Rail Potentials.

is wet and of low resistance. Instead of connecting one insulated return feeder to the middle point of every line, as indicated in Fig. 17, a number of such feeders may be connected to a number of properly selected points in

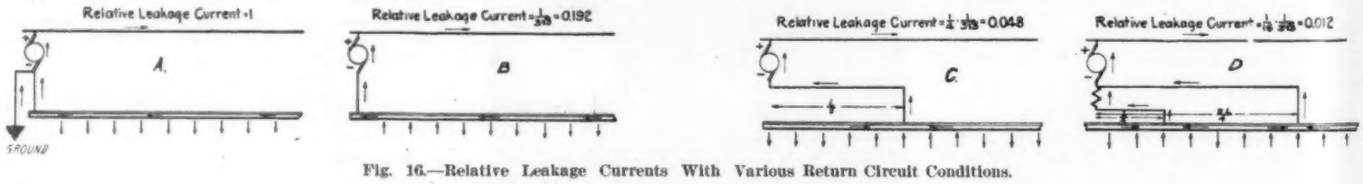

Leakage Current with Bus-Bar Grounded and with No Return Feeder Copper = 1/1 (Assumed Unity)
Relative Leakage Current = 1
A.
Relative Leakage Current = 1/5 = 0.192
B
Relative Leakage Current = 1/4 · 1/5 = 0.048
C.
Relative Leakage Current = 1/4 · 1/20 = 0.012
D
GROUND

Fig. 16.—Relative Leakage Currents With Various Return Circuit Conditions.

An illustration of such an insulated return feeder system, proportioned for constant drop, is shown in Fig. 15. In this illustration it is assumed that the negative bus-bar is at zero potential, and that the return feeder connection points on the rails are maintained at a potential of 10 volts with reference to the negative bus-bar. Under these circumstances, there is no tendency for current to flow from the rails between points where feeders are connected to the rails. The drop of 10 volts in the return feeders has also been removed from the rails.

The possibilities in the way of reducing stray currents by means of properly proportioned insulated return feeders was clearly shown by Mr. George I. Rhodes, in a paper entitled "Some Theoretical Notes on the Reduction of Earth Currents from Electric Railway Systems by Means of Negative Feeders," published in the Transactions of the American Institute of Electrical Engineers for 1907. A few of the figures from Mr. Rhodes' paper are reproduced in Fig. 16 together with diagrams illustrating the application of these figures. It will be seen that with the negative bus-bar grounded through a ground connection of negligible resistance, in addition to being connected to the rails at the power station, the greatest amount of stray current is produced which is assumed unity for purpose of comparison. This is illustrated by Diagram A of Fig. 16. Disconnecting the negative bus-bar from ground connections, but not from rails, reduces stray currents to one-fifth of their former value, as illustrated by Diagram B of Fig. 16. Disconnecting the negative bus-bar from ground connections and from the rails at the power station, and returning the current by means of one insulated return feeder from the center of the line, reduces stray currents to 5 per cent of their former value, as illustrated by Diagram C of Fig. 16. By using two insulated return feeders with the negative bus-bar insulated, the stray currents are reduced to 1.2 per cent of their former value, as illustrated by Diagram D of Fig. 16. It, therefore, can be seen that very

shown connected to the negative bus-bar at the power station only. It is seen that as the result of this, all of the current used on the eight railway lines flows in the rails toward the power station. The stray currents which leak from the rails to ground also concentrate in

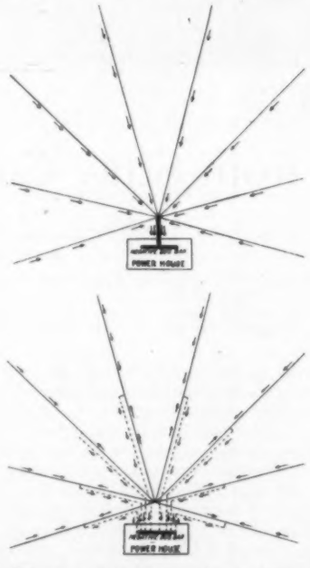


Fig. 17.—Diagram Showing Trolley Lines Radiating Out From Power Station With and Without Insulated Return Feeders, and Showing Path of Return Currents.

every line. In this way the drop in the rails and consequently also the stray current produced can be reduced to any desired value.

The reduction of drop in potential in rails, for the purpose of minimizing electrolysis, is the basis for various regulations and ordinances which have been enacted for the purpose of protecting underground metallic structures from electrolysis. For example, the well-known English Board of Trade Regulations limit the maximum allowable potential difference between any two points in the rails to 7 volts. In Germany, a joint committee representing the electric railway, gas and water interests has adopted a regulation limiting the average allowable potential difference between any two points in the rails to 2.5 volts within a district encircling the urban district by a radial distance of 2 kilometers. Beyond this circle, the average potential drop in the rails must not exceed 1 volt per kilometer.

Where railway return circuit improvements have been made to such an extent that there are no longer any excessive drops in the grounded rails, it is generally found that stray currents on underground pipes are reduced to small and often negligible amounts. Where, however, stray currents which are considered to be too large for safety are still found on such underground pipes after the railway return circuit has been thoroughly improved, then it is frequently possible and feasible to apply one or more of the other remedial measures, such as insulating joints in the pipes to take care of the small remaining stray current. Such other remedial measures, as bonding or insulating joints in pipes, must, however, never be applied unless the railway return circuit has been improved sufficiently to eliminate all excessive drops in the grounded rails.

SUMMARY AND CONCLUSIONS.

Experience shows that where there is serious trouble from electrolysis caused by large stray currents leaking from street railways, the bulk of this trouble is due to

defective rail bonding, to ground connections from the negative bus-bar, and to lack of return feeders to bring current back from the rails to the power station. While stray currents can only be entirely eliminated by insulating the return circuit by the use of a double trolley, either overhead or in conduit, it is nevertheless a fact which is not generally appreciated, that where large stray currents exist, these can always be reduced to a small fraction of their present value by removing all ground connections of the negative bus-bar, and installing insulated return feeders proportioned for equal drop from radially-disposed points in the track system located at some distance from the power station. By this method the rails are drained of current and any desired part of the voltage drop can be removed from the rails and transferred to insulated conductors from which currents cannot leak. In Europe, such radial insulated return feeders for bringing current back from the rails to the power station are made necessary by regulations limiting the allowable drop in voltage in the rails, and in most cases such installations of insulated return feeders have substantially removed serious trouble from electrolysis. This system of minimizing stray currents by means of radially-disposed insulated return feeders has also been installed in a number of American cities, and the method is gradually being recognized as by far the best for minimizing stray currents. This system in fact removes the root of the trouble, by draining the rails of current and receiving voltage drop from the rails and thus preventing substantial leakage of current through ground, and is therefore correct in principle. The railroad companies frequently object to this system claiming that it is prohibitively expensive. This is certainly not the case, as is evidenced by the fact that the method is in general use in Europe and in a number of American cities to-day. The fact is that in many electric railways there is practically no installation of negative feeders and the railway companies are often not willing to install even a moderate amount of return feeder copper. A mistake is often made in confusing the radial insulated return feeder system with paralleling the rails with copper. Of course where the negative bus-bar is connected to the rails at the power station, and these rails are paralleled with copper feeders, the drop in the rails is reduced in the proportion that the conductivity of the return circuit is increased, but no part of the drop is actually removed from the grounded rails. The amount of copper paralleling the rails that would be required to reduce stray currents to a negligible amount would in all large systems be absolutely prohibitive. This, however, is not the case with the radial insulated return feeder system. With the latter system any desired reduction in rail drop and consequently in the amount of stray current can be secured, independent of the amount of copper installed, the amount of copper being determined by the allowable drop or power loss in the return circuit. The railway company can divide the annual charge of interest on copper invested and operating expense in any ratio within wide limits without affecting the amount of stray current produced from the system. The pipe owning companies suffer constant expense on account of stray railway currents in the form of repairs and depreciation of their underground structures, and in the form of liability for accidents, and this can be reduced with certainty to any desired extent, short of complete elimination, by the assumption on the part of the railway company of expense in the form of interest and power charges for its return circuit. The railway companies should in all fairness assume this expense and responsibility. If the railway companies would apply as much engineering knowledge and money to their negative circuits as they do to their positive circuits there would be but little trouble from electrolysis. The pipe owning companies should co-operate with the railway companies by affording them access to their pipes for making necessary measurements, etc. After a railway company has installed a reasonable and fair return circuit, it sometimes happens that it is desirable to eliminate any remaining current on pipes by the use of properly located insulating joints. Under these circumstances the pipe-owning companies should be willing to co-operate with the railway company in the installation of such joints.

In the decree recently filed in the celebrated Peoria case, the railway company is enjoined and restrained from injuring the property of the water company by electric current escaping from the rails or structures of the railway company. No particular method for preventing escape of current is prescribed in the decree, because the Court in its decision has already stated that a Court does not have the power to prescribe by injunction any specific system, and that this power resides only with legislative bodies. In its decision the Court, however, lays great stress upon the insulated radial return feeder system, which is spoken of as a quadrilateral system. The decree also requires the water company to co-operate with the railway company to the extent of giving the railway company access to its piping system for the purpose of measuring flow of current upon its system, and of determining whether injury from electrolysis is being continued, in order that the railway company may determine whether it is complying with the terms of the decree. It is evident from this decree that the expense of providing a proper return circuit for the railway system so as to minimize escape of current falls entirely upon the railway company as it should in all fairness. One section of the decree states that within six months after the expiration of one year after the date of the decree, the railway company may apply for a hearing on the question whether it should be permitted to make an experimental use of the drainage system, in order to ascertain whether such drainage or limited use thereof can be practically applied to the piping system.

It appears from the decision and the decree that the railway company must within one year improve its return circuit so as to prevent as much as possible the escape of stray electric currents from its systems. If, after this has been done, it is found that stray currents still exist on the piping system, then the railway company may apply to the Court for a hearing to determine whether the water company should be directed to permit the railway company to try a drainage system as an experiment to remove the remaining current harmlessly. A drainage system such as contemplated as a possible final measure by the Peoria decree, when properly controlled so that only small currents are drained from the pipes, does not have the objectionable and dangerous features of promiscuous bonding where large currents are made to flow on the pipes as often found in American cities, and may even be a safe final method where the soil conditions are favorable and where the underground structures are all continuous electrical conductors. It nevertheless seems to the author very unfair that any pipe-owning company should be compelled by a Court order to permit an electric railway company to use its pipes as a return conductor for its railway system, even to the slightest extent. If the Court does not have the power to compel the railway company to adopt any specific method for eliminating the danger from electrolysis, then it certainly should not impose any specific method upon the pipe-owning companies. The latter may for example prefer to remove any small remaining stray currents by means of properly located insulating joints.

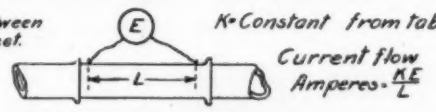
It is the author's firm conviction that such remedial measures as pipe drainage or insulating pipe joints should be used if at all only as a final measure and never until the return circuit of the railway has been improved so that only small amounts of stray current remain on the underground structures. This view appears to be entirely in accord with the Peoria decision, and is certainly in accord with the best engineering practice.

A Modelling Wax that gives perfectly smooth impressions and can be melted up and used over as often as desired, is made, according to *Drogen Rundschau*, of 4 parts white wax and 1 part shellac. In making up the preparation the ingredients are melted together over a slow fire, while stirring.

TABLE FOR DETERMINING CURRENT FLOW ON PIPING FROM MILLIVOLT DROP ALONG CONTINUOUS LENGTH OF PIPE.

L = Distance between contacts, feet.

E = Instrument reading in millivolts.



K = Constant from table.

Current flow Amperes = $\frac{KE}{L}$

Wires must not span joints.

AMERICAN WATER WORKS ASS'N STANDARD CAST IRON PIPE.

Resistance = 1 lb. ft. = 0.001 44 Ohms.

Design.	Nominal Size of Pipe	Wt. per Foot Exclusive of Hub.	Resistance per Foot. Exclusive of Hub.	K Current for 1 Millivolt Drop per ft. of Continuous Pipe.
	inches	pounds	ohms	amperes
100 ft. Head, 43 lbs. Press.	8	37.3	0.000 038 6	25.9
	10	51.4	0.000 028 0	35.7
	12	65.1	0.000 022 1	45.2
	14	81.4	0.000 017 7	56.5
	16	97.6	0.000 014 8	67.6
	18	115.0	0.000 012 5	80.0
	20	133.6	0.000 010 8	92.6
	24	174.3	0.000 008 3	120.0
	30	244.3	0.000 005 9	170.0
	36	289.0	0.000 005 0	200.0
	42	421.0	0.000 003 4	294.0
	48	530.0	0.000 002 7	371.0
	54	650.0	0.000 002 2	455.0
	60	781.0	0.000 001 8	556.0
150 ft. Head, 65 lbs. Press.	8	39.8	0.000 036 2	27.6
	10	54.7	0.000 026 3	38.0
	12	70.2	0.000 020 5	48.8
	14	87.4	0.000 016 5	60.7
	16	106.0	0.000 013 6	73.6
	18	126.0	0.000 011 4	87.7
	20	146.0	0.000 009 9	101.0
	24	195.0	0.000 007 4	135.0
	30	275.0	0.000 005 2	192.0
	36	370.0	0.000 003 9	256.0
	42	478.0	0.000 003 0	333.0
	48	603.0	0.000 002 4	417.0
	54	742.0	0.000 001 9	526.0
	60	965.0	0.000 001 5	666.0
200 ft. Head, 86 lbs. Press.	6	27.8	0.000 051 8	19.3
	8	42.5	0.000 035 9	29.5
	10	57.7	0.000 025 0	40.0
	12	75.4	0.000 019 1	52.4
	14	94.7	0.000 015 2	65.8
	16	114.0	0.000 012 6	79.4
	18	138.0	0.000 010 4	96.2
	20	161.0	0.000 009 0	111.0
	24	215.0	0.000 006 7	149.0
	30	307.0	0.000 004 7	213.0
	36	411.0	0.000 003 5	286.0
	42	539.0	0.000 002 7	371.0
	48	677.0	0.000 002 2	455.0
	54	853.0	0.000 001 7	588.0
	60	1026.0	0.000 001 4	715.0
250 ft. Head, 109 lbs. Press.	6	29.1	0.000 049 5	20.2
	8	44.3	0.000 032 5	30.8
	10	62.3	0.000 023 1	43.3
	12	80.6	0.000 017 9	55.8
	14	101.0	0.000 014 3	70.0
	16	123.0	0.000 011 7	85.5
	18	147.0	0.000 009 8	102.0
	20	174.0	0.000 008 3	121.0
	24	232.0	0.000 006 2	161.0
	30	335.0	0.000 004 3	233.0
	36	456.0	0.000 003 2	313.0
	42	595.0	0.000 002 4	417.0
	48	753.0	0.000 001 9	527.0
	54	941.0	0.000 001 5	667.0
	60	1152.0	0.000 001 3	769.0
300 ft. Head, 130 lbs. Pres.	4	17.7	0.000 081 4	12.3
	6	30.5	0.000 047 2	21.2
	8	47.0	0.000 030 6	32.7
	10	65.6	0.000 021 9	45.7
	12	85.7	0.000 016 8	59.5
	14	108.5	0.000 013 3	75.2
	16	132.0	0.000 010 9	91.8
	18	158.0	0.000 009 1	110.0
	20	189.0	0.000 007 6	132.0
	24	253.0	0.000 005 7	175.0
	30	364.0	0.000 003 9	252.0
	36	501.6	0.000 002 9	345.0
	42	653.0	0.000 002 3	436.0
	48	824.0	0.000 001 7	589.0
	54	985.0	0.000 001 5	667.0
	60	1282.0	0.000 001 1	909.0
350 ft. Head, 158 lbs. Press.	4	18.2	0.000 079 1	12.7
	6	31.3	0.000 045 1	22.1
	8	48.7	0.000 029 6	33.9
	10	70.0	0.000 020 6	48.6
	12	91.0	0.000 016 8	63.3
	14	114.0	0.000 012 6	79.3
	16	140.0	0.000 010 3	97.1
	18	167.0	0.000 008 6	116.0
	20	193.0	0.000 007 2	139.0
	24	248.0	0.000 005 4	185.0
	30	396.0	0.000 003 6	278.0
	36	551.0	0.000 002 6	385.0
	42	711.0	0.000 002 0	500.0
	48	906.0	0.000 001 6	625.0
	54	1148.0	0.000 001 3	769.0
	60	1360.0	0.000 001 06	936.0

American Gas Institute. Standard Cast Iron Pipe.

Res. 1 lb ft = 0.001 44 ohms

Nominal Size of Pipe	Wt. per Foot Exclusive of Hub.	Resistance per Foot Exclusive of Hub.	K Current for 1 Millivolt Drop per ft. of Continuous Pipe.
inches	pounds	ohms	amperes
4	17.26	0.000 083 5	12.0
6	27.25	0.000 053 9	18.5
8	38.06	0.000 037 9	26.4
10	51.09	0.000 028 2	35.5
12	67.2	0.000 021 4	46.8
16	102.8	0.000 014 0	71.5
20	139.7	0.000 010 3	97.2
24	186.8	0.000 007 72	130.0
30	257.7	0.000 005 59	178.0
36	345.1	0.000 004 17	240.0
42	452.9	0.000 003 18	316.0
48	608.5	0.000 002 37	423.0

Standard Wrought-Iron Pipe.

Res. 1 lb ft = 0.000 181 ohms.

Nominal Size of Pipe	Wt. per Foot Exclusive of Hub.	Resistance per Foot. Exclusive of Hub.	K Current for 1 Millivolt Drop per ft. of Continuous Pipe.
inches	pounds	ohms	amperes
⅛	0.24	0.000 752	1.33
¼	0.42	0.000 431	2.32
⅜	0.56	0.000 324	3.09
½	0.84	0.000 216	4.63
¾	1.12	0.000 162	6.17
1	1.67	0.000 108	9.27
1¼	2.24	0.000 081	12.40
1½	2.68	0.000 068	14.80
2	3.61	0.000 050	19.90
2½	5.74	0.000 032	31.60
3	7.54	0.000 024	41.70
4	10.67	0.000 017	58.80
6	18.76	0.000 009 7	103.00
8	28.18	0.000 006 4	156.00
10	41.07	0.000 004 5	222.00
12	49.00	0.000 003 7	271.00

Standard Steel Pipe.

Res. 1 lb ft = 0.000 21 ohms.

Nominal Size of Pipe	Wt. per Foot Exclusive of Hub.	Resistance per Foot. Exclusive of Hub.	K Current for 1 Millivolt Drop per ft. of Continuous Pipe.
inches	pounds	ohms	amperes
⅛	0.24	0.000 873	1.15
¼	0.42	0.000 500	2.00
⅜	0.56	0.000 376	2.66
½	0.84	0.000 251	3.99
¾	1.12	0.000 188	5.32
1	1.67	0.000 125	7.99
1¼	2.24	0.000 094	10.70
1½	2.68	0.000 079	12.80
2	3.61	0.000 058	17.20
2½	5.74	0.000 037	27.40
3	7.54	0.000 028	35.80
4	10.67	0.000 020	50.70
6	18.76	0.000 011	88.80
8	28.18	0.000 007 4	134.00
10	41.07	0.000 005 2	191.00
12	49.00	0.000 004 3	234.00

The Motor Truck in Manufacturing*

Its Utility, Adaptability, Capacity and Economy Under Suitable Conditions

By Harold Whiting Slauson

THERE is probably no place where the motor truck is surrounded by more favorable conditions for efficient operation than in the average manufacturing business. Machines are used throughout for the production of the goods; why should not mechanical power be employed for the transportation of the raw and finished material? No matter how large or how small the plant may be, and regardless of the size, nature, or quantity of the product, a motor truck transportation, delivery, and hauling service *must* show a marked saving in time and money over the horse type, if the former is properly installed and operated under efficient conditions. As power-driven machines have reduced the cost of manufacturing goods, so will motor-propelled trucks lessen the hauling charges for those goods.

These may seem like sweeping statements, but they are attested to by thousands of successful truck installations in hundreds of different kinds of manufacturing businesses. The success of these proves the adaptability of the motor vehicle, for each of these manufacturing lines may require its trucks to operate under conditions absolutely different from any of the others. By means of special bodies and a wide selection of types and sizes of power plant, a variety of combinations can be obtained, the proper selection of which will allow almost any operating conditions to be fulfilled. A few years ago the motor truck cost more to install and to operate than the horses and wagons required to perform the same amount of work, and this excess expenditure was charged to advertising; but the modern motor truck has been brought to the point where it can show an actual dollar-and-cents saving, and even on this one merit alone can the mechanical means of transportation compete with the horse. Figuring interest on the investment at 6 per cent, depreciation at 10 per cent, chauffeurs' wages higher than those paid to horse drivers, and insurance premiums and repairs at a larger amount than would ordinarily be required in practice, the properly-organized truck installation will show a saving of from 10 to 30 per cent over the maintenance expenditure of a horse system.

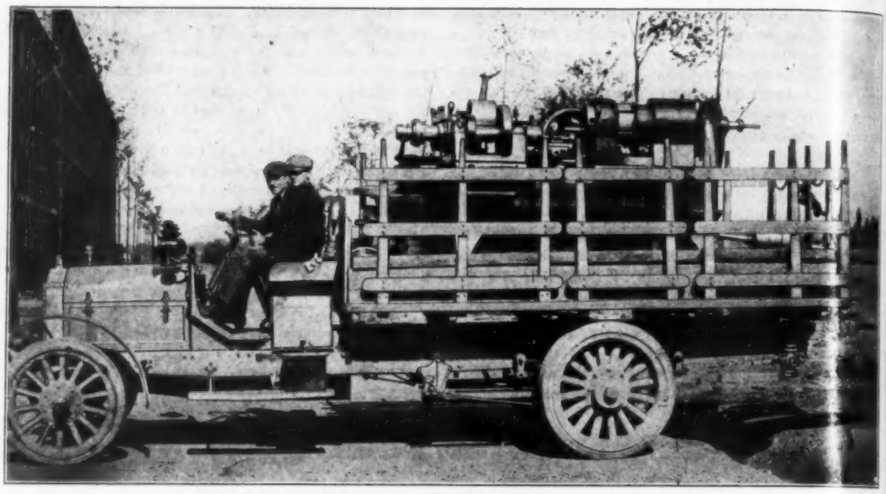


Fig. 1.—Auto Truck Carrying Machinery to the Freight Depot.

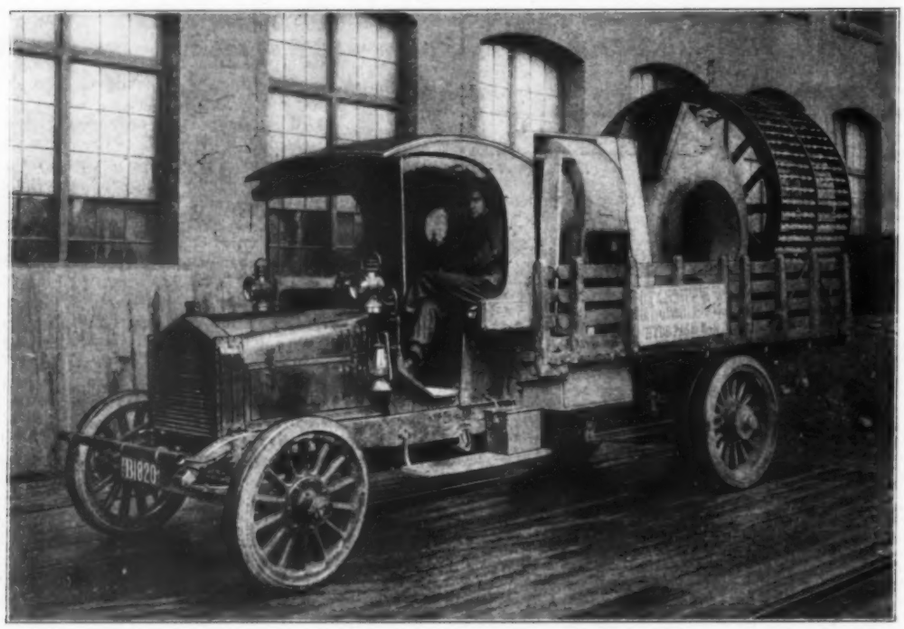


Fig. 2.—Five-ton Worm-driven Truck Used by a Large Manufacturing Company for Carrying Heavy Castings and Large Parts of Machinery.

From an investigation of many installations made by one company, it was found that interest, insurance, garage expenses, and driver's wages constituted a daily fixed charge of $5.32 for a 5-ton truck. This charge, of course, continues whether the truck is in use or not, and remains constant regardless of the mileage covered. Operating expenses, such as those for tires, gasoline, lubricating oil, and allowance for repairs, overhauling, and depreciation amounted to 15½ cents a mile. For a 50-mile day, the total expense would amount to the fixed charge of $5.32, plus 50 times the 15½ cents per mile operating cost, or $13.07 per day.

This strikes the keynote of the secret of a successful truck installation. Inasmuch as the $5.32 represents a fixed charge that is not affected by the distance that the truck travels, it is evident that the cost per ton-mile will be reduced as the daily mileage is increased. A 5-ton truck traveling 50 miles a day has a ton-mile capacity of 250. Inasmuch as there is but little difference between the operating cost of a loaded truck and one running empty, it will be seen that the hauling expense per ton mile may be reduced to slightly over $0.05. This is on the assumption, however, that the truck will be run at full load at all times—a condition which, obviously, cannot be attained in the average installation. If the truck is run loaded in one direction and returns empty, the hauling cost per ton-mile will be doubled.

There are, consequently, four broad, general conditions to be met in order to secure the most efficient installation. The truck must be selected with due regard to its capacity; its work must be so laid out and routes so arranged that but a minimum amount of time will be spent in idleness, and its active hours must be employed in hauling loads approaching as nearly as possible to its rated capacity; its construction must be such that the necessity for repairs will

Fig. 3.—A Six and One Half Ton Truck Hauling Steel Girders for an Office Building Construction.

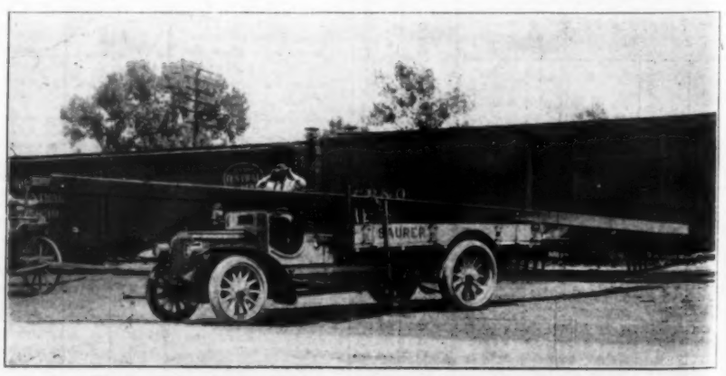


Fig. 4.—Six and One Half Ton Truck Hauling Long Steel Girders.

* Reproduced by courtesy of the Editor of *Machinery*.

be infrequent; and its design must be so simple that it may be handled and overhauled by the ordinary intelligent driver or machinist, thereby eliminating the expenses of high-priced help. The fulfillment of the first two of these conditions rests with the purchaser, with the co-operation of the manufacturer of the truck, while the last two depend upon the truck builder and

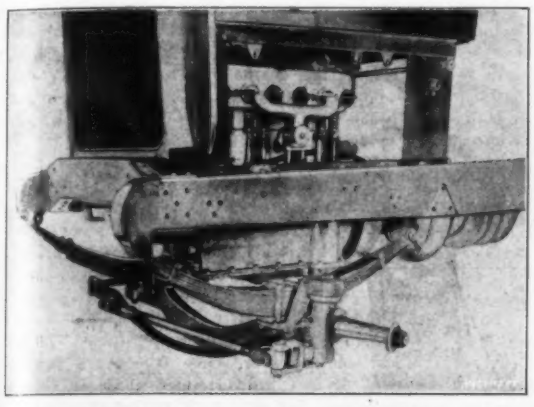


Fig. 5.—The Front of a 5-Ton Truck Chassis. All the Vital Parts Are Properly Protected in Case of Collision.

designer—but with the necessary co-operation of the purchaser.

The selection of a truck with regard to its capacity is an important consideration, but one too often overlooked. A 5-ton truck should not be purchased to conduct a 2-ton hauling business, unless expansion in the near future is to be provided for. To haul two tons in this case will cost nearly as much as to haul five, and such an installation would probably show a loss. Of course, it rests with the purchaser as to whether the expansion of this end of his business will, in the future, call for larger trucks, or a greater number of small vehicles, but the installation departments of the truck factories will help him with this problem.

While it is necessary that the trucks should be run fully loaded as much of the time as possible, the fact must not be overlooked that loads in excess of the capacity of the machine will cause the ton-mile hauling cost to increase rapidly. In fact, it is probable that to this tendency on the part of owners and drivers may be attributed the majority of the failures of commercial vehicle installations. By a constant 25 per cent overload, the life of the tires may be reduced by two thirds.

Inasmuch as a high mileage is essential to efficient motor truck operation there should be as little delay as possible in loading and unloading, and trips and routes should be so arranged that the truck may be given an opportunity to take advantage of its speed and large territory-covering ability. But even though the area to be covered by the truck might, of necessity, be restricted to the factory yard, the use of special loading and unloading devices may easily overcome what would otherwise be serious obstacles to an efficient installation. If the factory is situated some distance from the freight yards, and the truck can be utilized to carry the finished products to the point of shipment and to bring back raw material on the return trip, conditions are nearly ideal, and such an installation should show a marked saving over any other arrangement. In fact, an installation that will allow the truck to travel loaded in both directions is so obviously destined to be successful that the only ques-

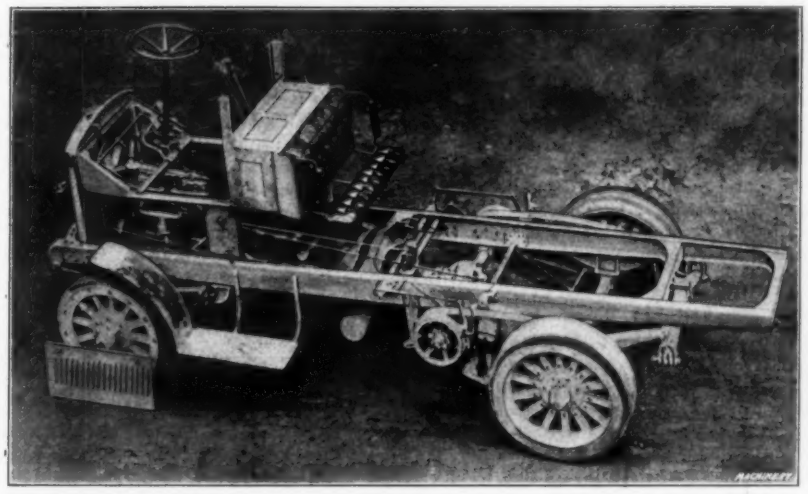


Fig. 6.—Chassis of a Five-ton Truck, Showing the Accessibility of the Motor Located Under the Driver's Seat, Which Can be Folded Back.

Fig. 7.—A Good Example of the Load That Can Be Put on a 5-Ton Truck.

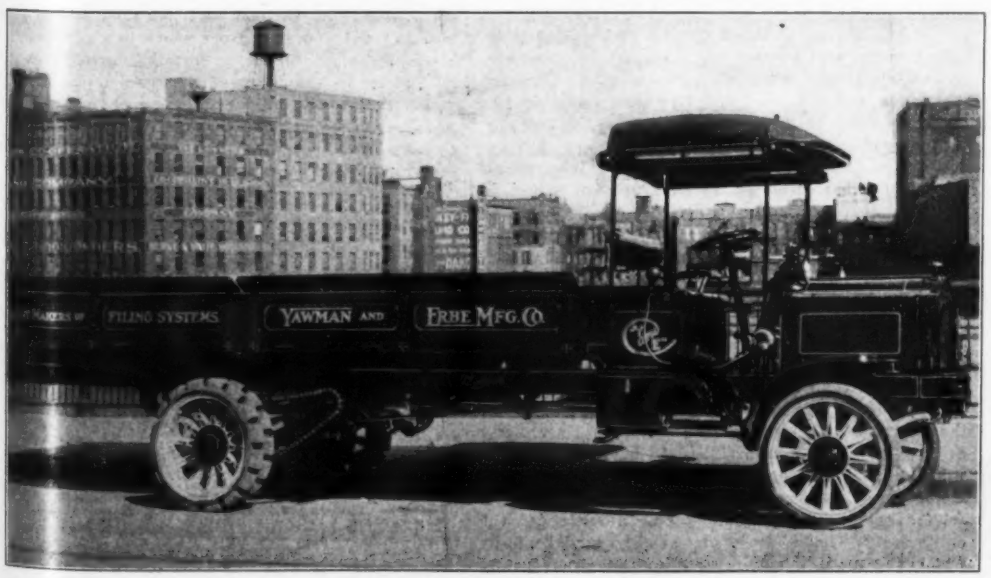


Fig. 8.—Truck With Long Overhanging Body at the Rear, Facilitating Loading at a Platform. This Truck Does the Work of Four Teams of Horses at an Average Cost of $9.92 per Day, or at a Saving of About $10.

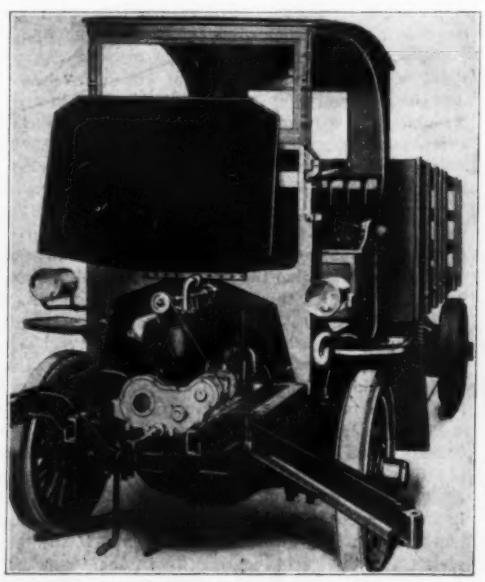


Fig. 9.—Removable Power Plant of an Auto Truck, Ready to Be Slid Out of the Chassis.

tion to be considered is as to which of the many trucks on the market would be best adapted for the particular requirements of the business. Many manufacturing businesses employ one or more trucks to do "odd jobs" around the yard. As work of this type will consist, probably, in moving heavy machinery or other material, and in traveling under load from one building to another, trucks used for this purpose should show good returns on their investment.

The very multitude of chassis sizes and types and body designs from which the purchaser may choose is striking evidence of the variety of purposes to which the motor truck may be put. Special bodies may be obtained to meet certain requirements, and these may be mounted on any size or type of chassis. It is probable that the average manufacturer will find the conventional stake body the type best suited to his needs. This may be mounted on a chassis of the ordinary length when heavy loads are to be carried, or on a chassis of extra-long wheelbase if its regular load is to be bulky or long.

It is not, however, only because of the unusual opportunity to run loaded a large part of the time that a truck will appear to unusually good advantage when used in a manufacturing business. The fact that a motor truck is a *machine* indicates that it will be well cared for, and that unusual facilities will be already at hand for its overhauling and repair. Probably every tool that would be used in a complete garage and repair shop will be found in the average large factory. There will probably be a large force of men familiar with all kinds of machinery, and consequently the motor truck will not be the "strange creature" that would be the case were it replacing the horse transportation system of many another line of business. This enables the factory to retain its old drivers. Thus, a complete garage and repair shop may be installed and equipped in the factory yard at but little additional expense, and the attendant saving in storage and overhauling charges will represent a large item. If the truck installation consists of but one vehicle, it may be advisable for a time, at least, to store the machine in a public garage, but even this will not bring the expense above that figured for a 5-ton truck in a preceding paragraph, as this charge was included in the estimate.

If the equipment consists of three or more trucks, it will undoubtedly prove advisable to equip a private garage and employ an expert whose sole duty shall consist in overhauling the vehicles and keeping them in perfect repair. In this case the drivers need only understand the control of the car, and are not required to be experts themselves. Consequently, a considerable saving may be made in chauffeurs' wages, and this forms the third advantage to be found in a motor truck installation in a manufacturing business.

The question of service is naturally an important consideration. No matter how well constructed a motor truck may be, it will require a certain amount of care and attention, and the engine must be overhauled occasionally. If several trucks are used, much of this work may be done at night, and if the power plants are thus kept continually in the top-notch of condition, there need be but little fear of interference with their work during the day. It was not long ago that, in large installations, one truck in every ten was used as a reserve machine. In other words, it was assumed that only 90 per cent of the trucks would be available for service. To-day, through better management of the installation, as well as through improved design, the average percentage of idle trucks has been reduced to about two. Some builders have provided removable power plants that can be used to replace the engine that requires overhauling. These power plants are of the "unit" type and include, besides the motor, the clutch, transmission, and, in some cases, the radiator and all electrical equipment. These parts are all attached to the motor or its base and the entire power plant may be lifted out after the removal of two or three bolts. Thus, by the use of but one extra removable power plant, nine or ten trucks may be kept in practically continuous service, and yet each motor may be thoroughly overhauled as often as necessary.

The unit power plant, which includes the transmission mounted on an extension of the motor base, is not used on the majority of heavy trucks—although some of two, three, and even five-ton capacity will be found so designed. The average five-ton truck is chain-driven from two sprockets mounted at each end of a jack-shaft extending from the transmission case and located about in the middle of the frame. There is at least one notable exception to this design, however, in the form of a shaft-driven five-ton truck that employs a worm and gear for transferring the power from the propeller shaft to the floating rear axle. Practically all of the trucks having a capacity of over three tons use the twin, or dual, solid tires on the rear wheels. Such a wheel is provided with one set of spokes, but possesses two rims, thus giving the effect of an exceedingly wide tire. Instead of using one wide tire on each wheel, however, two narrower tires are mounted on the single felly.

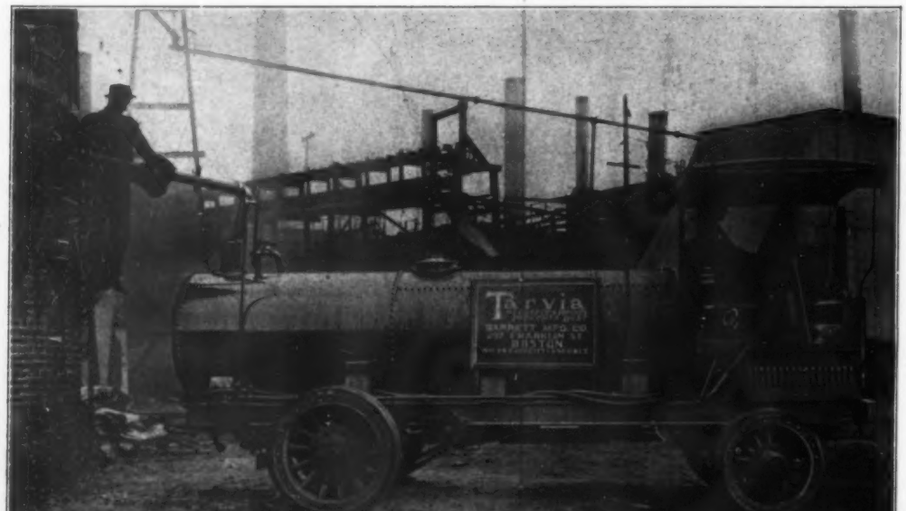


Fig. 10.—Tank Truck Used for Spraying Dust-laying Oil on Roads.

The power plants of the larger trucks are similar to many of those used on the high-power touring cars. The ordinary 5 or 10-ton truck is generally driven by a 30 or 40 horse-power motor located in the forward portion of the chassis, either under a conventional bonnet or under the driver's seat. In the latter design, the seat tips back or to the side in order to render the motor easily accessible. The gear ratios of the truck are much higher than are those of the pleasure car employing a power plant of equal size, for the speed of a 5-ton truck should not exceed 12 miles an hour, while that of one of 10 tons capacity should be restricted to 7 or 8 miles an hour. Some 3-ton trucks are designed to attain a maximum speed of 15 miles an hour—and even higher—but the governors used on the majority of the motors restrict their speed to about 1,200 revolutions per minute, and consequently the maximum speed of the truck will depend upon the gear ratios employed. On one truck, the governor is attached to the driving shaft, so that the speed of the car itself, rather than that of the motor, will be restricted.

It is evident that many designers have kept in mind the desire of truck owners to employ former horse drivers—or other men unskilled in handling a power vehicle—instead of expert chauffeurs, for the modern motor truck is of exceedingly "foolproof" construction. In fact, continued overloading constitutes about the only means—aside from downright vandalism—by which the average motor truck can be injured. By means of heat-treated and other special steels in the motor, transmission, and other parts of the frame and running gear subject to unusual strain or wear, the present-day truck can successfully withstand a remarkable amount of abuse; but there are right and wrong ways of handling even the most invulnerable truck, and many designers have bent their efforts toward eliminating all possible sources of abuse. In some, the spark control lever has been removed and a fixed point of ignition used in its stead, so that the driver cannot run the motor at slow speeds and with closed throttle when the spark is advanced. On other trucks, an automatic spark advance and retard has been installed by means of which the speed at which the motor is operated regulates the point of ignition. In still another design, a spark lever has been used, but instead of placing this on the steering wheel—as is usually the case—it has been located on the dash where it cannot be reached as easily by the driver as can the throttle. It is assumed that there will be less temptation to "monkey" with the spark if the lever is not so conveniently located.

Although some of the heavy trucks are provided with planetary transmission, the majority employ the sliding type with either the selective or progressive method of shifting—the latter being in the majority. Modern transmission gears are so accurately cut and are made of special steels of so high a grade that it seems well-nigh impossible to "strip" them. As an added precaution, however, some trucks are provided with special devices which render abuse in this direction impossible. On one such device, the gears are in mesh at all times and each is provided with an individual clutch. The gear control lever is used to engage the various clutches, and thus the different speeds are obtained without any actual sliding or clashing of the gears, and the changes may be made without releasing the main clutch. Other designs employ a notched quadrant which prevents the movement of the gear-shifting lever until the main clutch is disengaged. Still a third system allows the gear-shifting lever to be moved, but the gears themselves are not slid into position until the clutch is released. This action is obtained by means of a bar cam which brings the tension of a spring into play against the gear to be moved. A back-cut on the jaws of the positive clutch with which each gear is provided, however, prevents the movement of any of them while the jack-shaft is revolving, and as this jack-shaft will continue to turn as long as the main driving clutch is engaged, the gears cannot be changed until conditions are proper for the shifting.

From 60 to 80 per cent of the load on the modern motor truck is carried over the rear wheels. This insures effective traction and enables the truck to negotiate slippery roads and steep hills with comparative ease. Designers are realizing that, because of its surroundings and the nature of its work, the average motor truck will be subjected to many a hard knock from exterior sources, in addition to those it may receive at the hands of a careless driver. Consequently all vulnerable parts are protected as far as possible from contact with any obstacle which the heavier portions of the truck might strike. For example, a heavy cross-member may be riveted to the forward portion of the frame to serve as a guard for the more delicate radiator, and all of the motor, transmission and protruding shafts or studs may rest within the confines of the frame proper. On some trucks, the motor sub-frame and radiator are mounted on separate springs to relieve these parts of the shocks and jars of travel that will not be absorbed by the heaviest body springs.

In fact, the modern truck is so well designed and constructed, and there is such a variety of body and chassis types and sizes from which to choose, that the blame for an unsuccessful installation may generally be laid to the purchaser of the truck and his system, rather than to the builder. There are, of course, many problems to be met and changes to consider, but each problem can be solved and all difficulties overcome especially well in a manufacturing business

Method of Recording Finger Prints

HITHERTO it has been customary, in following up criminal clews, to make a permanent record of finger prints by photographic means. This method, however, has a number of obvious disadvantages. Thus, for example, cases arise in which the finger print to be recorded is not accessible to an ordinary camera. Or again, it may be located upon some rounded surface which cannot be properly focused. In a recent number of *Umschau* Dr. Heindl describes one or two new methods which overcome these difficulties. The first method consists in dusting the impression—which is always more or less greasy—with some colored powder, and then pressing against it a paper treated with a mixture of fifty grammes wax, fifty grammes paraffine and twenty drops of glycerine. A very excellent inverted copy is thus obtained, and as the paper is entirely flexible, any kind of a surface can be thus treated.

The second method makes use of photographic gelatine paper in place of that prepared as above.

Sinhalese Iron and Steel of Ancient Origin—II*

Beginnings of the Iron Age

By Sir Robert Hadfield, F.R.S., Sheffield

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 1918, Page 221, October 5, 1912

OPINIONS BY VARIOUS AUTHORITIES WITH REGARD TO THE SO-CALLED IRON AND BRONZE AGES.

In a most excellent sketch of the history of iron in his "Metallurgy of Iron and Steel" (1864), Dr. John Percy, F.R.S., stated that iron is so rapidly corroded and wasted away by the oxygen of the air, even in dry climates, that it is not to be wondered at that only few ancient specimens have remained preserved.

Dr. Percy also believed that from metallurgical considerations it is not unreasonable to suppose that the so-called age of iron preceded the age of bronze, or, if not, was concurrent. The metal of the latter age required more skill to produce than iron, whose process of production in its simplest forms is not so difficult. As Dr. Percy points out, if a lump of red or brown hematite be heated for some time in a charcoal fire, well surrounded by or embedded in the fuel, it will be more or less completely reduced so as to admit of being easily forged at a red heat into a bar of iron.

Singular to say, the author cannot find even one analysis of an ancient iron specimen by Dr. Percy, whose eminence in the metallurgy of iron and steel during the last generation was renowned, thus showing that specimens of such material were indeed *raræ aves*. The author therefore believes that the ancient specimens now described for the first time represent an accurate analysis of ancient iron, in this case made about 1,400 years ago. They also probably represent the type of material produced at a much earlier date.

Mr. St. John V. Day's "The Prehistoric Use of Iron and Steel," published in 1877, and Beck's "Geschichte des Eisens" (1903), in five volumes, covering no less than about 6,000 pages, are both remarkable books on iron and steel in reference to their past history.

Day believes, with Dr. Percy, that the use of iron has a very ancient origin, and preceded the so-called Bronze Age. Day says "that the earliest of substances with which man was acquainted was unquestionably iron, and almost certainly steel; . . . and that this is true whether we look to Egypt, Babylonia, or Proto-Chaldea and Assyria, on the one hand, or China on the other."

Day points out that iron has been discovered in the Great Pyramids, the oldest buildings known to men.

Lepsius, an Egyptologist of the highest rank, says that "considering the frequent working of granite in large masses, which can be proved near the fourth Manethoic dynasty, it cannot well be doubtful that since that time, and indeed earlier, iron and the hardening of it were known."

Many tablet pictures show workers wielding tools which could not very well be those other than of iron or steel, and Maspéro, in the interesting recent correspondence with Osmond, referred to in this paper, admits the wall pictures of Egypt show workers handling tools which were surely of iron or steel.

Dr. Percy, therefore, seems fully justified when, in writing to Mr. Day, he makes the following important statement: "I become more and more confirmed in my opinion that archæologists have been generally mistaken concerning the so-called Iron Age. I am collecting further information on the subject from time to time, and as yet have met with nothing in opposition to the opinion above mentioned."

Prof. Max Müller, so Day points out, stated that "in the Homeric times knives, spear-points, and armor were still made of copper, and we can hardly doubt that the ancients knew the process of hardening that pliant metal, most likely by repeated smelting and immersion in water." The author quite agrees with Day that such a statement on the face of it cannot be correct, for copper is not hardened by immersion or cooling in water, but, on the contrary, it is softened. Moreover, no one has yet been able to harden copper in the manner that iron does when combined with carbon. If such an art had been known, it is difficult to imagine that the knowledge would have been entirely lost; it would have been too valuable. The world has yet to discover a method of hardening copper, in the sense of producing a material which can be compared with hardened steel. Alloys of copper with tin and other elements are well known, but their qualities render them unsuitable for purposes where iron and steel are used.

In the same manner Day, rightly, the author thinks, took the late Right Hon. W. E. Gladstone to task with regard to his laborious investigation of the Homeric epic, when announcing "the age of copper is the first and oldest of the metallic ages, which precedes the general knowledge of the art of fusing metals." Day gives good reasons for his opinion, with which it is not possible adequately to deal here. The reader is referred to Day's most interesting and valuable work, and to a useful paper by the late secretary of our Institute, Mr. Bennett H. Brough, on "The Early Uses of Iron," in the *Journal* of the Iron and Steel Institute, 1906, No. I., page 233.

REMARKS ON THE PAPER COMMUNICATED IN THE YEAR 1795, BY DR. PEARSON, F.R.S., TO THE ROYAL SOCIETY, ON "INDIAN WOOTZ STEEL."

Before dealing in detail with the specimens examined in this research, reference may be made to the salient points of Dr. Pearson's paper previously mentioned. The specimens of Wootz steel described by him, which were stated as being sent over by Dr. Scott, of Bombay, in 1795, were not claimed to be of ancient origin, but apparently represented steel which was being manufactured in India at that time—that is, the closing years of the eighteenth century. It is not, perhaps, surprising that, notwithstanding Dr. Pearson's paper, no record was then, or even until much later, made available as to the composition of Wootz iron or steel. This is quite natural, as it is only within the last twenty-five or thirty years that really reliable and accurate methods of chemical analysis have been made possible to the worker in this field of metallurgical research. In this connection the author well remembers the fact that about thirty years ago his father one day showed him, as a great achievement, a certified analysis of a specimen of steel. In that analysis, for which a fee of fifteen guineas had been paid, five elements had been determined, probably most of them not very correctly, at all events as compared with the accuracy possible at the present day. That was but a generation ago. It is now possible, at very small cost, to obtain complete and accurate analysis of the composition of iron and steel, not only of simple types, but of the most complex compositions. It is impossible, therefore, to withhold our admiration of the work of the chemist, which in a comparatively few years has led to this great advance in methods of analysis, whether as regards accuracy, rapidity, or low cost.

As a proof of this it may be interesting to here mention that the author has been informed by one of the very able directors of Messrs. Krupp, Dr. Ehrensberger, who has done so much to advance metallurgical knowledge in Germany, that in 1910 the total number of analyses carried out in their laboratory was no less than 416,728. The writer's own firm carried out in the same year a total of 39,653 analyses. Therefore, in the metallurgical world there must now be made many millions of analyses in each year. Even but a generation ago such a possibility was hardly dreamt of.

Although the chemical composition of the Wootz steel in question was not put on record, Dr. Scott, who forwarded the specimens to Dr. Pearson, describes these as "admitting of a harder temper than anything known in that part of India; that it is employed for covering that part of gun-locks which the flint strikes, that it is used for cutting iron on a lathe, for cutting stones, for chisels, for making files, for saws, and for every purpose where excessive hardness is necessary." Also that it "cannot bear anything beyond a very slight red heat, which makes it work very tediously in the hands of smiths." It is added that it "could not be welded with iron or steel, to which, therefore, it is only joined by screws and other contrivances." Dr. Scott also pointed out that "when working, if heated above a slight red heat, part of the mass seems to run, and the whole is lost, as if it consisted of metals of different degrees of fusibility." "Working with Wootz is so difficult that it is a separate art from that of forging iron;" and "the magnetical power in an imperfect degree can be communicated to this substance."

Dr. Pearson further describes the specimens received by him as being in the shape of a round cake of about 5 inches in diameter and 1 inch in thickness and weighing about 2 pounds. He stated that "under the file I found Wootz much harder than common bar steel not yet hardened," and than Huntsman's cast steel not yet hardened.

This reference to Huntsman's steel, which has been the subject of several papers by the author before the Iron and Steel Institute and other technical bodies, is very interesting, and indicates that the work of Huntsman was well known at that date, 1795. Dr. Pearson's paper contains a table giving the specific gravity of Wootz and several other specimens of steel and iron, in which it was stated that the specific gravity of these Wootz specimens varied from 7.166, quenched while white hot, to 7.647 in the forged condition, and that this compares with a specific gravity for Huntsman's steel of 7.771 in the hardened condition to 7.916 hammered. Reference is also made in the paper to the assistance given in forging Wootz by "that ingenious artist, Mr. Stodart." It is not a little flattering to metallurgists to note that an expert worker of steel was mentioned in such terms, the description "artist" occurring several times in the paper. It may be here mentioned that it is probable Dr. Pearson's co-worker was the same Dr. Stodart who many years later assisted Faraday in preparing and investigating a large number of steel alloys. Although there was nothing very definite obtained from the experiments, they are most interesting, and will be found fully described in Philosophical Transactions, vol. cxii., page 253.

Naturally, owing to the then incomplete knowledge of special steels and of analytical methods, the results were incomplete, but nevertheless valuable as pointing the way.

Thus, even at that early period the importance of developing steel alloys made an appeal to the master mind of Faraday, although the actual accomplishment of his ideas was deferred for another sixty years. The first systematic presentation of a steel alloy research was probably that dealt with in the paper presented by the author to the Institute of Civil Engineers in 1888, entitled "Alloys of Manganese and Iron," in which a complete correlation of method of manufacture, composition, analysis, physical properties, and mechanical and electrical tests were set forth.

In the paper referred to by Dr. Pearson will be found an account of an elaborate research as to the "Effects of Fire and Oxygen Gas Conjointly," "Experiments with Diluted Nitrous Acid," also with "Diluted Sulphuric Acid." Much time and attention were given to determining the nature of the gas obtained from the Wootz so dissolved. It is very curious to note the exceedingly painstaking character of the attempts made to reach conclusions, which, of course, could not then be verified for want of the requisite scientific and technical knowledge. Probably the chief want was the chemist, to whom metallurgists owe so much for the first advance in true and accurate metallurgical knowledge. Dr. Pearson estimated the "quantity of carbon in the Wootz and steel to be nearly equal; and that quantity to be about one third of the hundredth part, or 1/300 of the weight of these two substances," whatever may have been meant by that statement. As an illustration of the extraordinary opinions which then found acceptance from men in responsible positions, and who must be assumed to have had the advantage of the best scientific and technical training of the day, Dr. Pearson states that from some of the solutions so obtained he observed there was "a deposition of white matter and formation of green crystals in a liquid." The green crystals were obviously those of sulphate of iron, and the white matter was the siderite of Bergman, which is now believed to be phosphate of iron. It is curious to note, as showing to what lengths investigators of that day were driven for an explanation of the properties of steel, that Dr. Pearson says: "Common steel, which is all made by cementation, is very malleable when white hot, only perhaps because it contains iron which has escaped combination with carbon."

Dr. Pearson concluded by saying that the Wootz steel which he examined must have been made directly from the ore, and that it had never been in the state of wrought iron. The author refers to this in connection with facts he brings before the Institute with reference to the specimens of ancient steel obtained in Ceylon, which appeared to be rather of the nature of wrought iron than steel, although some of the specimens appear to have been cemented.

(To be continued.)

Growth of Gas Bubbles.—Prof. C. Barus in the American *Journal of Science* records the peculiar observation, that air bubbles on the walls of a beaker full of water swell greatly when the beaker is placed in an atmosphere of hydrogen.

* Excerpts from a paper read before the Iron and Steel Institute, May 9, 1912, and published in *Engineering*.

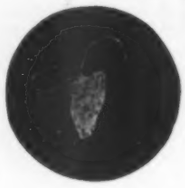


Fig. 1.—Normal Free-swimming Form.

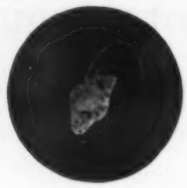


Fig. 2.—First Stage in Reproduction by Fission.

Development of the Monadidea

A Fruitful Field for Microscopic Study

By Aubrey H. Drew

Fig. 3.—Second Stage in Reproduction by Fission.

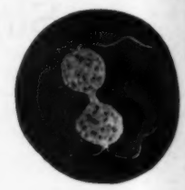


Fig. 4.—Third Stage in Reproduction by Fission.

BIOLOGY is as profoundly concerned with the study of the smallest, as with that of the largest organisms, but the class Mastigophora deserves special attention from microscopists for many reasons. The discovery of the Trypanosomes, and their intimate relation to sleeping sickness and many other diseases peculiar to tropical regions, has concentrated a considerable amount of attention on the Trypanomorphidæ, and numerous biologists are engaged in all parts of the world in working out their life-histories. The order Monadidea, which comprises the least differentiated forms of the Mastigophora, is well worthy of careful inquiry, as, although at present none of this order have been demonstrated to be the causative agents in disease, yet they are allied to the Trypanosomes, and in them we have a type of organism which is on the very fringe of organized life. The opportunities for discovering new and interesting forms are great, as the order has been very much neglected, and comparatively few of the organisms have been figured and described. Moreover, it is extremely desirable that we should possess a full knowledge of the life cycles of the Protozoa, and an excellent field is open in this direction to microscopists. It is not difficult, I think, to understand why this order has been so much neglected, as the organisms comprised therein are exceedingly minute and consequently escape the notice of the average amateur microscopist, unless he is provided with first class and high powered lenses. The professional worker is usually so taken up with organisms such as the bacteria that, even if he comes across the monads in the course of his researches, he has no time to spare for organisms that are not yet definitely connected with disease.

Again, to acquire any real knowledge of the development of these minute forms, it is necessary to spend long and wearisome hours of constant observation at the microscope, and the majority of workers prefer a study that does not tax their patience to the uttermost. It is, however, to the amateur, who has already done yeoman service to microscopic science, that we must look to work out these organisms, and with such a wide and little explored field before them it is much to be hoped that ere long our knowledge of these organisms and their wonderful life cycles will have greatly advanced. The Monads are universally distributed in water containing decomposing organic matter, either animal or vegetable. They are colorless flagellata, with from one to an indefinite number of flagella, and a single nucleus; they also possess a simple vacuole system.

METHODS OF NUTRITION.

The nutrition of the order may be holozoic, saprophytic, or parasitic, but probably never holophytic. Formerly, the Monads were regarded as essentially saprophytes, but increased knowledge of the order, and particularly a careful study of their life histories, has shown that almost invariably a certain amount of holozoic nutrition takes place at some period in the organism's development. In certain forms holozoic nutrition plays a very important part, saprophytism being reduced to a minimum. In the new monad, *Monas sarcophaga*, described by myself in *Knowledge* in November, 1910, holozoic nutrition is by far the most important means of obtaining food, and in this particular form the organism even goes so far as cannibalism. Some forms, and perhaps all, in a greater or less degree, are saprophytic, obtaining their nutrition from the water in which they live by absorbing the soluble disintegration products from the breaking down of complex protoplasmic molecules by bacteria. The food in these cases is predigested by the enzymes secreted by the various bacteria present. Most forms, however, combine a certain amount of holozoic nutrition with the saprophytic, these organisms being conveniently designated as Mixotrophic. With regard to these mixotrophic forms, bacteria and small protoplasmic particles, both animal and vegetable, form the food, while in the *Monas sarcophaga* other monads of the same or different species are ingested.

REPRODUCTION.

Two methods of reproduction occur in the Monadidea, a sexual and an asexual. As is the rule among the Protozoa, reproduction by fission is the commonest. Some appear to divide into many smaller forms, as first recorded by the late Dr. Dallinger. The nucleus in all cases appears to go through a karyokinetic process prior to division. This asexual process, however, does not appear to be capable of maintaining the perpetuation of the organisms indefinitely, and in probably all cases an anisogamic method of reproduction also occurs. This is almost always obscure, and can only be observed by continuous and repeated observation of the same form over a length of time. Dallinger recorded that

Fig. 5.—Resting Stage Prior to Conjugation.

Fig. 6.—Conjugation.

he and Drysdale observed the same form continuously for five days before seeing any other method of reproduction than the asexual. In many, and possibly all cases, the spores which are formed in this method of reproduction appear to be more resistant to heat and other unfavorable conditions than are the parent forms, thus tending to keep the species from extinction. Dallinger and Drysdale recorded that in one form they studied, the parent organisms had a thermal death point of about 60 deg. Cent., while the spores from the sac did not perish till a temperature of 149 deg. Cent. was reached. I have found also, in the case of the *Monas sarcophaga*, that the normal form dies at a temperature between 52 deg. Cent. and 55 deg. Cent., while the contents of the sac formed by the conjugation of two forms withstood a temperature of 120 deg. Cent. for five minutes. This second method of reproduction does not in all cases appear to be truly anisogamic, for often the two conjugating gametes appear to be similar. In other cases the gametes may differ in some respects, generally one is larger and more granular than the other. In the forms where holozoic nutrition is met with, a digestive juice of an acid nature appears to be secreted. In the *Monas sarcophaga*, which habitually ingests other monads, as well as bacteria, I have shown that bacilli stained with blue litmus are almost instantly turned red after ingestion. In this particular organism this secretion appears to act with great rapidity, the edges of the ingested organism being speedily corroded, till only a small portion of undissolved material is left, which the monad finally expels.

STRUCTURE.

The structure of the monads is simple. They do not appear to be divisible into an extoplasm and an endoplasm, like the Amœba. The organism usually consists of transparent protoplasm, with granules embedded therein. Some of these granules are probably of a fatty nature, staining black with osmic acid. All the monads possess a nucleus, which is at times specially prominent. Even in the holozoic forms no mouth opening or anus is present, but in some species food particles are ingested at certain fixed points, usually at the base of the flagella, while undigested matter may be expelled from any point in the body, but usually from the opposite end to the flagella.

METHODS OF STUDY.

A few words on the methods adopted in the study of these organisms may be useful. The microscope used for this class of work must be a first rate one. It should have a tripod foot, and be perfectly steady in any position. A mechanical stage and compound substage are absolutely necessary. The microscope that I have used exclusively for my researches on these organisms is one of Messrs. Watson's instruments, and although it has been in daily use for over four years I have not found it necessary to make the slightest adjustment. With regard to lenses, these need not be numerous. The objectives I have found to be of most utility are the half inch, one sixth inch, and one tenth inch dry, and one twelfth inch homogeneous immersion. A high powered dry lens is essential for a large part of this work, as an immersion lens is objectionable when following a rapidly swimming organism for many hours. The one tenth inch dry lens that I have used for some time was made by Watson's, and is an excellent lens for this work, possessing the three necessary requisites, viz., excellent definition, capability of bearing a large solid cone from a good condenser, and ability to take high eyepiecing. The condenser used should be an achromatic one, the Abbe Illuminator being useless for critical work. The first requisite is some means of keeping a minute drop of fluid, containing the organisms, continually moist, and to prevent evaporation. Perhaps one of the best means is that devised by the late Dr. Dallinger, and described in "The Microscope and its Revelations." A very good arrangement I have used and which possesses the advantage of allowing several objectives on a revolving nosepiece to be used rapidly, is the following. A piece of thin cardboard has a circular hole cut out of it, and the card is then cut to a slightly smaller size than the ordinary three inch by one inch slide. This prepared card is then soaked in water, the excess of water removed, and the card placed upon a glass slide. Two cover glasses are used, one slightly larger than the hole in the card, the other being quite small, say three tenths of an inch in diameter. The drop of fluid to be examined is placed between these cover glasses and they are then placed on the card, the smaller cover glass being undermost; if a small vessel of water is now placed in connection with the card by means of filter paper the preparation may be kept for weeks without evaporation from the fluid under examination. It is almost impossible to get good permanent dried preparations of the monads, as if dried on a cover-glass, like bacteria, they break up, and the same result occurs if fixing agents are used; hence it is extremely difficult to photograph the organisms, and recourse must be had to the "Camera Lucida." Movement may be stopped by very dilute solutions of cocaine hydrochlorate. The drawings illustrating the life history of the monad herein described were done by means of a Camera Lucida and

* Reproduced from *Knowledge*.

Fig. 7.—First Stage in Formation of Sac.

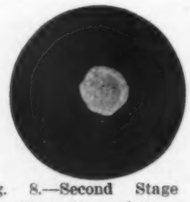


Fig. 8.—Second Stage in Formation of Sac.

Fig. 9.—Sac Discharging Spores.

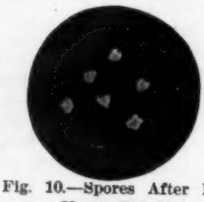


Fig. 10.—Spores After Four Hours Growth.

Fig. 11.—Sedentary Form Feeding.

Watson's "Holoscopic Immersion Paraboloid" which gives excellent dark-ground effects with high-apertured lenses. While engaged in working out the life history of the *Monas sarcophaga* I frequently observed small organisms somewhat resembling this monad, but of considerably less size and possessed of a peculiar jerky motion in swimming. The difficulties in working out this organisms's life history were not a few, but at length I have been able to accomplish it. This monad is an entirely new one, and on account of its peculiar vibratory motion in swimming I have named it *Monas vibrans*. This organism is closely related to, and belongs to the same sub-tribe as the *Monas sarcophaga*, viz., the Paramastigoda. It varies slightly in size, but not nearly so much as the *Monas sarcophaga*, the average size being about one four thousandth of an inch in length. The shape is bluntly triangular or conical, and the organism is very granular. It possesses two flagella, one long and one short (hence Paramastigote). The long flagellum is not as long in proportion to the body as that of the *Monas sarcophaga*, and is bent round somewhat like a fish hook; the small flagellum, which is exceedingly minute, and generally rather difficult to observe, arises from the base of the long one, and on its convex side (see Fig. 1). A nucleus, which stains somewhat irregularly with Hæmatoxylin, and a contractile vacuole are present. Swimming occurs by lashing of the long flagellum, aided by the smaller one. The long flagellum is vibrated with a peculiar whip-like motion which makes swimming very jerky and irregular. On following one of these forms by means of the mechanical stage, never losing sight of it in all its wanderings, it is found after a varying period to come to a standstill, and to adhere to the slide, apparently by means of a pseudopodial appendage. On coming to rest, the long flagellum is vibrated with great rapidity, thus causing small protoplasmic particles and bacteria to be swept toward the monad, many of which on touching the body, near the flagella, are engulfed by an amœboid action of the protoplasm. This stage of feeding may last for hours; in fact, the monad spends a large part of its existence in feeding in this way, swimming about at intervals apparently in search of pastures new. After some time two new flagella slowly appear near the normal pair. At first, these are very minute but rapidly grow larger and are in intense vibration; they swiftly diverge and at length get to the opposite pole to the normal pair. During this duplication of the flagella, the nucleus of the organism has become strongly developed and a division takes place; one of the two daughter nuclei now passes into each polar region, and with the two pairs of flagella now pulling from opposite ends a constriction suddenly appears across the body of the monad. From this time onward the constriction rapidly deepens, the two pairs of flagella pulling the organism into an hour glass shape, shown in Fig. 4. Finally, only an exquisitely-fine strand of protoplasm connects the two halves; this strand gradually gets thinner till at length it snaps, and the two organisms go free. Usually one of the two remains in the place where division took place, and at once commences to feed, while the other swims about for a time, till it also becomes stationary, and commences feeding operations. In a few instances I have observed feeding to go on during the actual process of division. The time occupied in this division is usually from fifteen to twenty minutes. For many months this was the only method of reproduction which I could observe. At length, however, I found that a certain proportion of the organisms, after swimming and feeding in the manner already described for many hours, became very sluggish and usually sank to the bottom of the drop of fluid under examination; the flagella lashed feebly, and the body of the monad became very pale and rather indistinct, the nucleus becoming considerably more prominent than usual and situated toward the posterior end of the monad. In several specimens I have noticed that the nucleus became somewhat striated at this stage. Finally, the flagella ceased movement, and the whole organism was perfectly motionless. At first, I came to the conclusion that some deleterious influence had killed the monad, and it was only after I had again and again failed to find any other method of reproduction than the asexual, that I determined to study these motionless forms further. A peculiarity of this monad is the length of time that it may remain in this quiescent condition. In four specimens I observed the average duration was about three and a half hours. The flagella then suddenly commence to lash again, at first very feebly, but finally rapidly, and the organism swims off. During the quiescent period, the body of the monad has become swollen and very pale, and the nucleus dense and glistening. These organisms now swim about with great rapidity. If one is now carefully followed, it will be found, after a varying lapse of time, to seize on one of the normal forms, to which it adheres, violent lashings of the flagella taking place. It is soon evident, however, that the larger organism is absorbing the smaller. Finally, this is accomplished, and very soon after this the monad, or more properly speaking the product of the fusion of the two organisms, comes to a standstill, rapidly gets globular, the nuclei disappearing and the flagella melting into the sarcode. A motionless globular sac is now left, of a slightly yellowish color. The time the sac remains in this condition apparently varies a good deal, perhaps owing to temperature, but thirteen to fifteen hours seems about an average. It then suddenly and without the slightest warning bursts, and a glairy fluid, containing excessively minute granules, is poured out. These granules at first show only Brownian movement, but later (about three hours) they grow somewhat larger, and then exhibit amœboid movements. From this time they rapidly grow larger, minute flagella are developed, and they swim away, small but perfect counterparts of their parents. It will be seen that this organism, both in its microscopic appearance and development, bears a striking resemblance to the *Monas sarcophaga*. It is easily distinguished, however, by its much smaller size, and the difference in the flagella. The average size of these organisms is very uniform, while the *Monas sarcophaga* shows considerable variations. Although I have specially and carefully looked for it, I have never found this monad to ingest other monads either of the same or different species. This, I think, is to be accounted for by two reasons. Firstly, the small size of the organism, and secondly, the flagella being smaller, do not appear to set up sufficient current to draw bodies of much greater size than bacteria toward the monad. A large number of these organisms furnish the *Monas sarcophaga* with food, and on several occasions I have had many hours' work spoilt by the monad under investigation finding a grave within the body of the former organism. Both these monads are, I believe, found exclusively in putrefying vegetable infusions and ponds in which much vegetable matter is in process of decomposition. The *Monas vibrans* multiplies far more freely and rapidly than the *Monas sarcophaga*. Both organisms may be cultivated in infusions of grass, but both rapidly die out as soon as the larger infusoria appear. The *Monas vibrans* almost invariably disappears from an infusion before the *Monas sarcophaga*, and from a large number of experiments I have come to the conclusion that both these organisms produce substances in the culture medium, which act deleteriously on them, and ultimately inhibit growth. I have recently found that if a quantity of an old culture, in which the organisms are dying out, be exposed to a temperature of 60 deg. Cent. and then filtered, the filtrate possesses markedly toxic properties toward these monads, a minute quantity added to a hanging drop preparation soon causing death. I am inclined to think that the toxic substances are of the nature of ferments, though at the present stage of my researches I cannot bring forward any direct evidence to support the view.

A Projection Lantern Without Objective

By Dr. A. Gradenwitz

In projection lanterns so far designed for opaque objects, a very powerful source of light had to be used or the size of projection to be reduced to a minimum on account of the enormous losses of light occurring in the optical system.

The projection lantern without objective designed by a Paris constructor, M. G. Massiot, for opaque objects and particularly for colored photographs as obtained by Prof. Lippmann's process, eliminates this drawback and has, in the case of Lippmann photographs, the additional advantage that the angle formed by the incident beam with the beam reflected by the plate is very small, which corresponds with the maximum accuracy of color reproduction.

This lantern consists of a sheet-metal case provided with a double condenser in the focus of which an electric arc is placed. The parallel beam coming from the condenser *C* lights the object to be projected which is placed in *A*. After reflection there the beam strikes a concave mirror *M*, 15 centimeters in diameter and 1 meter in focus, which forms on the screen an enlarged image of the object.

In order to reduce as far as possible the angle between the incident beam and the reflected beam received and thrown back by the object *A*, the mirror *M* should be placed as close as possible to the condenser *C*. To prevent stray light from reaching the screen, and there interfering with the regular image, a certain number of opaque partitions are provided to separate the different portions of the apparatus, and the conical beam coming from the mirror *M* passes through an opening *O* of very small dimensions, fitted with a shutter which is closed during manipulations.

Fig. 3 shows the arrangement of the carriage serving to carry the object or photograph plate to be projected.

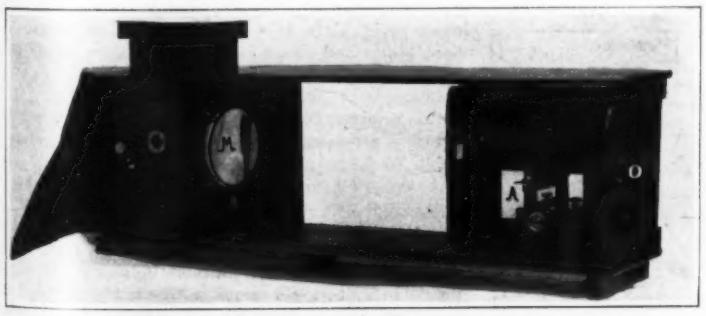


Fig. 1.—General View of Reflecting Stereopticon.

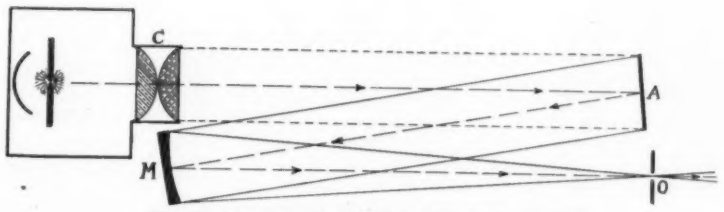


Fig. 2.—Diagram of Optical System of Lantern.

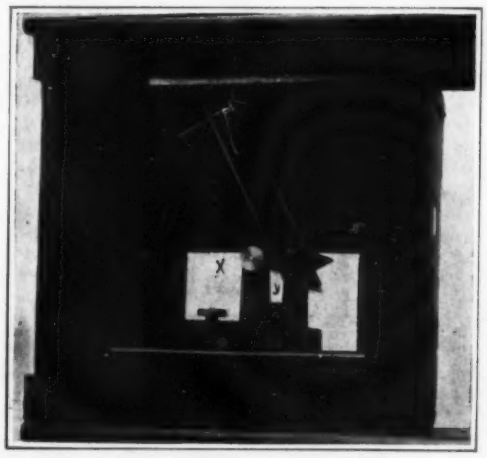


Fig. 3.—Carriage for the Object.

Its regulation can be effected from a distance by means of a rack and gearing. The orientation required to give a correct image is obtained by causing the carriage to rotate round two axes *X*, *Y*.

The advantages afforded by the mirror are the absence of any loss of light by absorption or reflection on lens surfaces. Moreover, the image is projected in its real orientation without any inversion as in the case of objectives, thus avoiding any alteration in the appearance of projected photographs, especially landscapes.

The mirror should be silvered at its surface and kept in good condition; it may be protected by a varnish. In case of need it can be resilvered by a very simple process.

It is a well-known fact that reflecting optical instruments present a number of advantages over refracting instruments. In the field of projecting lanterns these advantages have not hitherto been extensively made use of. The apparatus here described seems a move in the right direction, since, especially for the projection of opaque objects, reflection commends itself as the most natural principle to follow.

An Experimental Study of Vortex Motion in Liquids—III*

Lord Kelvins's Smoke-ring Model of the Atom

By Prof. Edwin F. Northrup, Ph. D., Palmer Physical Laboratory, Princeton University

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 1918, page 215, October 5, 1912

It was thought that in the case of two liquids of different densities, at least if these two liquids were not miscible, it ought to be possible to project a vortex ring of the less dense liquid through the liquid of greater density, as kerosene oil through water; but that it would not be possible to project a vortex ring of the liquid of greater density through liquid of less density, as a water ring through kerosene oil. Such was proved experimentally to be the case. If the gun was filled with kerosene oil, the ring was easily sent the entire length of the tank through water. To test the reverse case a cylindrical glass tube was provided 96 centimeters long and 12 centimeters in inside diameter. This tube was placed vertically and the gun fastened in its lowered end. The particular arrangement employed is shown in Fig. 6. Assuming the reverse to be true, if the gun projected a vortex ring of the denser fluid through the water, the ring should rise to the surface of the water, there break up, and the material of the ring settle down and again join the supply in the gun. Hence the vortex rings might be continually projected up the tube without renewal of the liquid. But unfortunately this was found not to be possible. The denser liquid employed was a mixture of carbon tetrachloride and kerosene oil. This mixture could be given any desired density, slightly less to slightly more than that of water, by varying the relative proportions of the two liquids. The mixture was colored red with Soudan III.

What occurred was this: if the blow on the diaphragm of the gun was light, the red liquid would issue from the hole a short distance as a large, shapeless globule, which, after rising a short distance, would sink back and rejoin the liquid in the gun. If the blow was hard, the liquid would leave the gun apparently starting in the form of a ring but would fly to pieces after going but a few centimeters. The results appear to be the same however the density of the red liquid be varied, so long as the density is at all greater than the water. It was thus conclusively proved that where two liquids are non-miscible, a vortex ring of the denser liquid is unstable in the lighter liquid and can not be projected and preserve its integrity.

To determine whether vortex rings might be made to solidify and to produce solid rings, so to speak, a large earthenware jar was filled to the middle with cold water and from the middle to the top with hot water. The gun was filled with melted paraffin and held in the hot water and pointed vertically downward. In this way liquid rings of hot paraffin were projected through the hot water into the cold water. Upon entering the latter, they at once solidified and preserved their form. In this manner a number of solid paraffin rings were obtained. For the sake of variety the paraffin was in some cases colored red with Soudan III. These rings were quite symmetrical and made very pretty objects.

Numerous modifications were made of the orifice in the gun, from which the rings issued, with a view of finding the most efficient form for the projection of circular rings. In one modification a short tube was inserted in the end of the gun, but it was found that the best and most perfect rings could be obtained from a simple, circular hole in the center of the front end of the gun. It appeared to make no difference whether the edges of this hole were sharp or not.

It soon became apparent, from these preliminary experiments, that, if the peculiarities of these rings were to be described to others, and, if what happened was to be precisely determined when the rings formed and especially when two rings united, it would be necessary to take photographs of them.

PHOTOGRAPHY OF VORTEX RINGS.

The problem which was presented of photographing fluid vortices proved to be one of very great difficulty. It was, indeed, over a year after the first attempt at solution before a satisfactory one was found. In the beginning the facilities available were inadequate and interruptions were frequent during the course of the experiments.

At the outset it was decided to take stereoscopic views, practically full size, and, if possible, so nearly instantaneous that, with the swiftest motions, there would be no lack of sharpness in the photographs. A little calculation will show the briefness of the interval required for a successful exposure. Some of the negatives were made from rings moving at the rate of 20 millimeters in 1/80 of a second. If the photograph is to show clear and sharp under a lens no part of the ring should move over 1/20, or certainly not over 1/10 millimeter, during the time of an exposure. Hence, the exposure should not last longer than from 1/16,000 to 1/32,000 of a second.

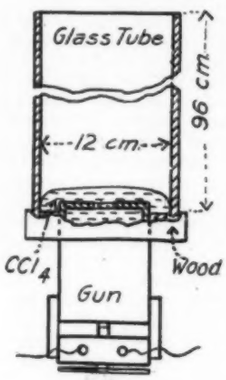


Fig. 6.

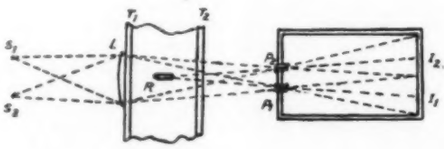


Fig. 7.

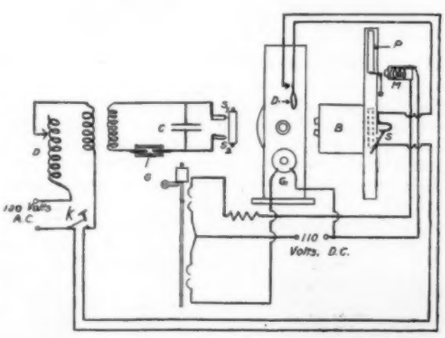


Fig. 8.—Apparatus for Producing Light-flash.

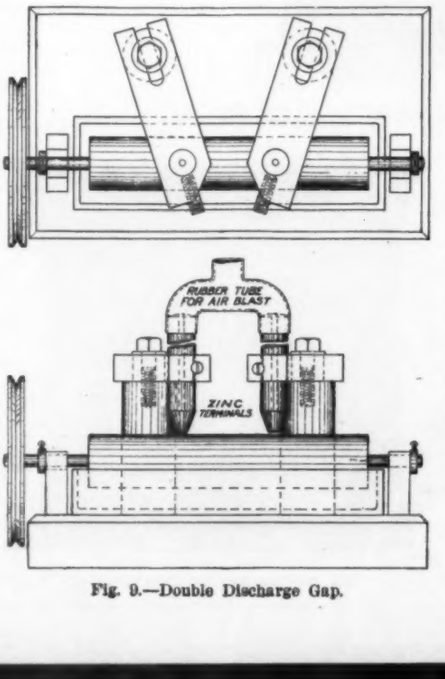


Fig. 9.—Double Discharge Gap.

No mechanical shutter could be constructed to give so short an exposure. At first this fact was not fully appreciated, and a few preliminary trials were made in which a steel shutter moved by a powerful spring was used. Views were obtained, but the delicate details were all absent. It was then rightfully concluded that the photographs must be made with an electric spark, which preferably should not last over 1/50,000 of a second. As the intensity of the light must be great in proportion as the time of exposure is reduced, and as the light must pass through 12 centimeters of water besides two plates of glass and at least two lenses, it was necessary to devise means of obtaining a light of very great intensity and quantity.

In photographing falling drops of a liquid, as was done so beautifully by Worthington, the time of fall through a given height in air could be depended upon as fairly constant. The reproducibility of the speed of the vortex rings could not, however, be so depended upon. Experiments showed that it was impossible to so exactly regulate the force of the blow on the diaphragm of the gun and other necessary conditions that the velocity of the rings could be relied upon to be twice quite alike. All difficulties, except the last, were overcome, and this proved not to be serious in the end. The optical method employed giving complete success, and which I think could not be improved upon, was as follows:

A plano-convex lens, L (Fig. 7) 12.5 centimeters in diameter, was held in a frame against one of the glass sides of the tank. The lenses, p_1 and p_2, of the stereoscopic camera were placed as shown in the diagram, 25 centimeters from a plane midway between and parallel to the sides of the tank. The camera was adjusted to give a focus at 25 centimeters. The two stereoscopic images of the ring R would thus appear full size upon the photographic plates. Two sources of light, s_1 and s_2, were located back of the lens in such positions that the image of s_1 was focussed on the lens p_1 and the image of s_2 on the lens p_2. This arrangement projected upon the camera plates I_1 and I_2, two brilliant circular disks of light of uniform brightness. The ring thus appeared in the camera as a dark object against a brilliantly lighted background.

If a suitably moving photographic plate and the vortex ring R are as indicated, when instantaneous flashes simultaneously occur at s_1 and s_2 stereoscopic negatives are secured. A variety of makes of photographic plates 3½ by 6½ inches were tried. The most rapid plate tried was the Lumiere-Sigma, but Seed plates and Eastman plates also gave satisfactory results.

Methods of producing strong flashes of light at s_1 and s_2 received considerable study and experimentation before a satisfactory one was hit upon. The arrangement finally employed is shown in Fig. 8.

A generator of several kilowatts capacity supplied alternating current of forty cycles at 120 volts to the primary of a transformer having a transformation ratio of 1/100. In the circuit with the primary of the transformer there was a variable inductance D of low ohmic resistance. In circuit with the secondary of the transformer were the two spark gaps s_1 and s_2 in series and together in shunt with a high tension condenser C. The capacity of this condenser was 0.013 M.F. It was also found necessary in regulating the discharges at s_1 and s_2 to introduce an adjustable air gap at G. This air gap consisted of two steel rods 7 millimeters in diameter inserted into the opposite ends of a porcelain tube and separated from each other, near the center of the tube, by about 1 centimeter.

The problem was to make such adjustments that only one discharge would occur at the air gaps s_1 and s_2 during the time of each alternation of the generator current, or 80 discharges per second. It was arranged to have the dropping photographic plate P fall in 1/80 of a second through a distance equal to the diameter of one of the illuminated areas on the plate. Thus, two successive illuminated areas on the plate would touch, tangent to each other, and not overlap. If the plate were a long one, three or four round disks of deep black (in the negative) would be photographed upon it during its passage past the back of the camera box B. If the ring happened to be in the field of view while the plate was passing the camera box, two, three, or even four views, 1/80 of a second apart, might be secured.

The design of the spark gaps s_1 and s_2 was carefully

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worked out to give necessary uniformity in the discharges, as well as the greatest possible brilliancy and actinic power to the light.

The construction of this double discharge gap is shown in Fig. 9. It consists of three essential parts, a trough of mercury, a rotating cylinder of brass dipping into the mercury, and two upright rods of zinc to which the high-tension terminals of the transformer are

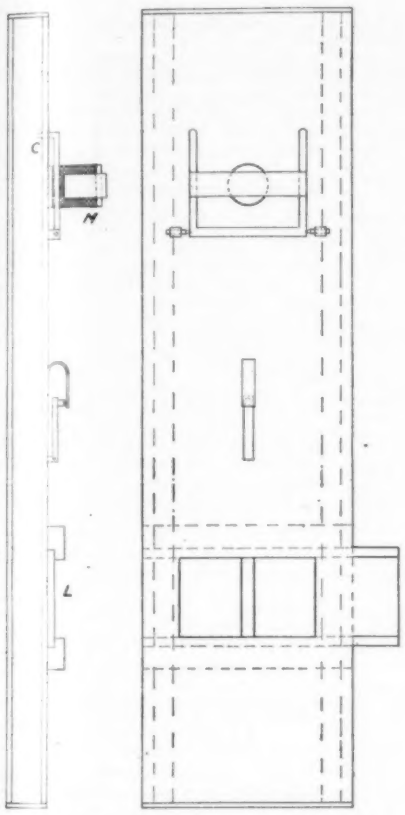

Fig. 10.—The Plate Slide.

joined. The discharge takes place between the amalgamated ends of the zinc rod and the amalgamated mirror-like surface of the rotating brass cylinder. The parts were made sufficiently large to run quite cool. A small motor maintained the brass cylinder in rotation at a moderate speed. It is thought an air-blast, as shown in the figure, would have been an improvement as tending to steady the discharge and keep it more regular. It too frequently happened that, due to inability to hold conditions constant, two or more discharges occurred during a half cycle and negatives were spoiled.

The plate slide is plainly shown in the general view, Fig. 3, and in more detail in Fig. 10.

As two plates had to be dropped at exactly the same time, a brass frame was constructed which held the two plates in rigid relation to each other. The plates were put in this frame, and when it was released by the magnet *M* and the catch *C*, Fig. 10, fell between two steel guides, shown in dotted lines. It was caught in a light-tight bag held below the slide. The guides for the plate frame were covered and made light-tight. A sliding door *D*, opposite the back of the camera, could be opened and ground glass inserted in place of the plate and in this manner the camera focussed.

The timing of the fall of the plates and the arrival of the ring in the field of view, so that it would be properly caught upon the plates, was accomplished in the following manner: A metal weight was so arranged that, upon releasing a catch, it would fall and make electric contact between two spring terminals in the circuit of an electric magnet, thereby releasing the plate frame; then, after a short definite time, the falling weight made contact between two other spring terminals, closing the circuit through the electromagnet gun. This timing device is shown in Fig. 11.

The relative positions of the first and second pair of contact springs could be adjusted to regulate, to a nicety, the interval between the release of a plate and the energizing of the gun magnet. To determine the proper positions at which to set the above two contacts the following procedure was adopted: There was first suspended in the tank of water a small disk (D_1, Fig. 8) at the exact position where it was desired that the ring should be at the moment of the exposure. When a ring was projected so as to strike this disk, it would close by its impact upon the disk an electric circuit. The contact was in circuit with the primary of the transformer and also in circuit with another contact (*S*, Fig. 8), which normally remained closed, but which the falling of the plate frame would open at a moment when the plates were in a position to receive the image of the ring. When the trigger released the contact weight, magnet *M*, Figs. 8 and 10, first released the plate frame, then after an interval the gun magnet G_1 was energized, and if the ring reached the disk before the plate frame reached its exposure position, the circuit through the transformer was closed and a flash of light at the spark gaps occurred. If, however, the plate frame reached the exposure position before the ring reached the disk, the primary circuit of the transformer was open and there was no flash of light at the spark gaps. An up-and-down adjustment was made of the pair of contact springs in circuit with the gun until a flash of light of the briefest possible duration was seen. This completed the timing, which meant that the ring reached the disk at the same instant that the plate frame and plate reached the exposure position. The disk which the ring was made to strike was then removed from the tank and the circuit short-circuited at *K*.

By the above procedure and adjustments everything was put in readiness for exposing the plates. To decrease the danger of fogging the plates, the work was usually done at night. When all was in readiness, the main circuit switch was closed to start the spark, and the timing weight was released. This last started the plate frame on its fall and after a short interval fired the gun. The plate frame was caught in a bag and carried to the dark-room for development. There resulted, on the average, about one drop out of five which gave photographs worth preserving. There were so many things to be kept in exact adjustment at the same time that numerous failures were inevitable. The expense for plates was considerable, and the innumerable trifles which persisted in going wrong at a critical moment were often discouraging.

After about thirteen first-class pairs of stereoscopic views had been secured and about twice this number of single views, it seemed that the research was consuming time out of proportion to the value of the results

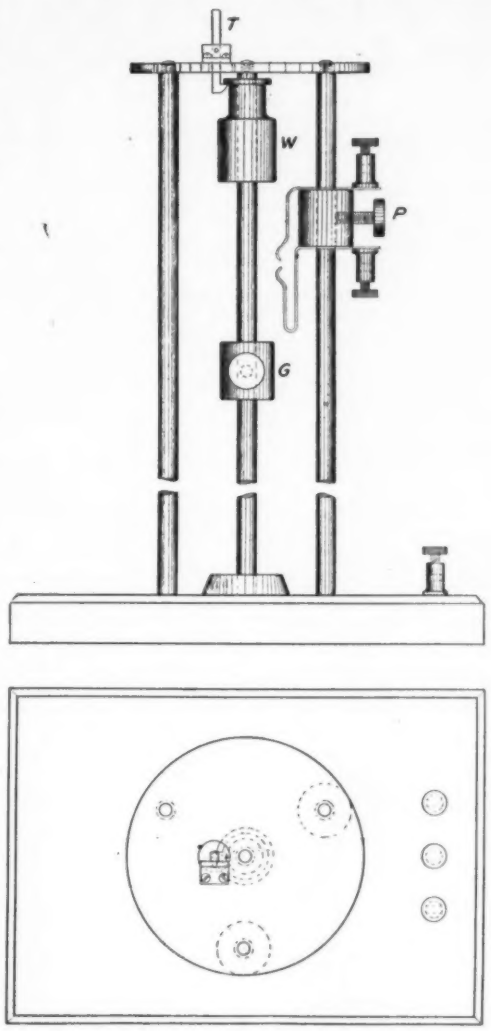

Fig. 11.—The Timing Device.

being obtained, and the writer did not feel justified in continuing the investigations further. The negatives secured, however, especially the stereoscopic ones, were sufficient to show, in a very adequate way, the precise character of the phenomena under investigation.

As the light was quite sufficient, a strong developer could be employed, and only about five minutes, as a rule, was consumed in the development of one pair of plates.

The developer employed was usually made up shortly before it was used and according to the following formula:

Water	10.7 ounces
Metol	0.5 gramme
Hydroquinon	2.1 grammes
Sodium sulphite	7.85 grammes
Sodium carbonate	14.3 grammes

This was put in a bottle with a tight glass stopper, and it was found to keep without deterioration when the bottle was kept filled. Before using it was diluted with an equal quantity of water.

(To be continued.)

Fish Culture on a Small Scale

It is the opinion of some competent authorities on pisciculture in France, that the rearing of fish on a small scale might prove a profitable occupation if conducted on systematic principles. Many persons are inclined to imagine that this industry can be only carried on successfully in rivers, streams, or lakes. Fish-culture, like bee-keeping, and many other rural industries, may be practiced to advantage even where such conditions do not obtain, and prove, in the hands of the small farmer or landowner, a source of profit and interest.

The supply of water for a small establishment need not be greater than that required for a small fountain, with a comparatively small inflow and outflow, such as is so frequently found in the gardens of country houses. Fish can be reared more profitably in small tanks than is the case where the young fry are turned out into a river or lake to shift for themselves, and where it is impossible to protect them from their many natural enemies, as well as from poachers. Where fish are reared on the "intensive" plan, that is to say, in small tanks and artificially fed, it is of the highest importance to breed only those kinds which fetch the highest prices in the market. For this reason the *Salmonidae*, or fish of the salmon family, which includes the trout and char, are preferable to carp, tench, eels, and other coarse fish, which are better suited for rivers or ponds. The former always find a ready market in all large towns, at prices ranging from 4 francs to 5 francs per kilogramme (36 to 40 cents per pound) while the latter seldom are worth more than 1 franc to 2 francs per kilogramme (9 to 18 cents per pound). During the close season as much as 10 francs per kilogramme ($1 per pound) is sometimes paid for trout in Paris.

The most suitable fish for small intensive culture are, without doubt, the rainbow trout of California (*Salmo iridcus*) and the North American brook trout (*Salvelinus fontinalis*), which is really a char. Both these fish have been acclimatized in Europe. The common migratory trout (*Salmo fario*) of our European rivers does not adapt itself so well to captivity as its American kindred, which, with artificial feeding, grow very rapidly.

The American brook trout (*Salvelinus fontinalis*) appears to be particularly suitable for intensive culture, growing with great rapidity. A specimen taken out of the water, weighing 100 grammes (3½ ounces), on January 1st last year, and weighed again five months later, had increased to 300 grammes (10½ ounces), or three times its original weight.

The rainbow trout, as well as the brook trout, thrives better in colder water than other varieties of fish, such as the carp or tench. The temperature of the tanks ought never to be allowed to exceed 64 deg. or 65 deg. Fahr. The tanks in which the fish are kept require to be well shaded, and may be established in some empty barn or suitable outhouse. The size is immaterial, but it has been found that long, narrow tanks, from 20 feet to 30 feet long, by 3 feet wide and 3 feet deep, are the most manageable size. They should be built of concrete, in pairs, above ground, so as to facilitate drainage. They should communicate with each other by a cross channel, provided with a suitable sluice. The sides and bottoms require to be well rendered with cement, in order to obtain a very smooth surface. Scrupulous cleanliness is essential in fish-culture to insure success.

The fish require feeding three or four times a day, with slaughterhouse refuse, chopped meat, horseflesh, etc.

It is found in France that fish of about a year's growth, weighing about 100 grammes each (3½ ounces), are the most marketable size, and this is the most profitable size to the breeder, for beyond that weight they consume, in proportion, a far greater quantity of food than the smaller fish.—*Journal of the Society of Arts.*

NEW BOOKS, ETC.

ELEMENTS OF APPLIED MECHANICS. By Herbert E. Cobb. New York: Ginn & Co. 12mo.; 274 pp. Price, $1.

The author, recognizing the close relationship between arithmetic, algebra, geometry, and trigonometry, seeks to present all four branches of study so that their practical connection will be apparent and their combined value in shop and laboratory may come to be readily understood and appreciated. The problems are all of a practical nature, such as will demonstrate and inculcate the principles which are necessary to actual useful accomplishment in future work.

HAND FORGING AND WROUGHT-IRON ORNAMENTAL WORK. By Thomas F. Googerty. Chicago: Popular Mechanics Company, 1911. 12mo.; 197 pp.; illustrated. Price, $1.

Hand-wrought ornamental iron work is a hobby and a handicraft that appeals to a large class of people, and justly so. There are few materials capable of more artistic shaping than iron, and many beautiful examples of forge work are extant in andirons, grilles, drawer-pulls, hinges, door-plates, and lamps. It is with such articles as these that the manual deals, inculcating correct principles of design, teaching the use of the equipment, and describing the various processes necessary to the molding and shaping of the material. Illustrations are numerous, and serve to make the directions readily understandable and immediately applicable to the particular task in hand.

NINETEENTH CENTURY ENGLISH CERAMIC ART. By J. F. Blacker. Boston: 1911. 8vo.; 534 pp. Price, $3.50 net.

This beautiful book contains 96 pages of plates and 150 line drawings. It is a very handsome specimen of book making, and will appeal to all connoisseurs. The collector of old English pottery and china and all others interested in ceramic arts have long needed a volume that is at once a practical guide combined with a history in pictures of the work of the old master potters. Mr. Blacker, who is undoubtedly the best authority on the subject, here presents concisely the story of the great industry represented by such old-fashioned potters as the Adams, Copelands, Mintons, Wedgewoods, Hadley and Linthorpe, as well as those of more recent date. The numerous illustrations, all carefully selected, present nearly every type and form of pattern, from the blue printed English and American scenery to the most elaborate painting, gilding and modeling, the masterpieces of the later potters. No collector can afford to be without Mr. Blacker's new book, which is the first in the Nineteenth Century Historical Art Series.

THE STEAM ENGINE AND TURBINE. A Text-book for Engineering Colleges. By Robert C. H. Heck, M.E. New York: D. Van Nostrand Company, 1911. 8vo.; 631 pp.; illustrated. Price, $5 net.

The author believes that the study of the piston engine and the turbine may be most profitably combined in one course. His text is constructed for class-room use, in such form as to make it easy for the instructor to select or omit as he may deem expedient. Rational theory, from fundamental concept to the fully-developed ideal engine, is first unfolded; after which this theory is compared with actual accomplishment, and an effort is made to impart the empirical knowledge that must bridge the gap between ideal and actual conditions. The turbine receives a comparatively small portion of time and attention since, its problems having been solved to a less degree than those of the piston engine, they fall less within text book scope. There is a new steam table that in certain aspects presents some advantages over the old Marks and Davis computations.

POWER AND THE PLOW. By L. W. Ellis and Edward A. Rumley. Garden City, New York: Doubleday, Page & Company, 1911. 8vo.; 318 pp.; illustrated.

It takes more power to turn the world's furrows than to run the world's factories. Agriculture is still the predominant labor of mankind, as it was of Adam. The first steam plow in the United States was probably that built by J. W. Fawkes of Philadelphia in 1858, which drew eight plows at three miles per hour over original prairie sod. This was a very good start. Illustrations of the work in hand show "the gasoline midget" making straight, mile-long furrows ten at a time. The modern tractor may weigh 25 tons, rate up to 120 brake horse-power, cost $3,000, and handle as many as fourteen plows. The authors set forth convincingly the advance made in applying the steam tractor to agricultural operations, beside giving extended historical and analytical sketches of the horse and the plow. They show, too, how this new element of power is about to bring forth a social and human readjustment that will be as far-reaching in its influence as was the advent of steam to our transportation systems. An imposing list of authorities are cited.

SCIENCE AND RELIGION HARMONIZED. Orbicular Theory of Cause and Effect. Book No. Three. By Samuel A. Motheral.

In this personally-issued pamphlet Mr. Motheral condemns the nebular hypothesis as beginning and ending in chaos, and the Darwinian theory as out of harmony with divine revelation. He declares that science must be re-established upon a right basic principle that shall recognize the pervasion of the natural order by an order supernatural. His orbicular theory, of infinite substance and infinite energy in one infinite globular mass, is framed with this recognition in view. Whatever the future may hold, the time has not yet come when science and orthodox religion may be satisfactorily harmonized and blended; we say this without detriment to the truths separately taught by both. Mr. Motheral's attempt to identify in the elements of substance and energy the three qualities of the Holy Trinity is the wildest sort of speculation, and his habit of leaping from some sound argument of science to theological rhapsody is helpful neither to science nor religion. If he would but endeavor to demonstrate one step at a time, not complicating the demonstration by extraneous considerations, he would see more clearly both the strength and the weakness of his own viewpoint and theories.

THE WESTINGHOUSE AIR BRAKE SYSTEM. Compiled and Edited by the World's Leading Air Brake Experts. Chicago: Frederick J. Drake & Co., 1911. 8vo.; 500 pp.; illustrated. Price, $2.

THE NEW YORK AIR BRAKE SYSTEM. Compiled and Edited by the World's Leading Air Brake Experts. Chicago: Frederick J. Drake & Co., 1911. 8vo.; 400 pp.; illustrated. Price, $2.

Very few laymen who glibly refer to "the air brake" realize the tremendous importance of this device with its numerous subsidiary inventions as an adjunct of successful modern railroading. A speed which it takes a locomotive five or ten minutes and several miles of travel to attain is entirely overcome by the automatic air brake in less than thirty seconds, and the train brought to a full stop within 1,200 feet. The two great systems of braking in use are the New York and the Westinghouse. The volumes in hand contain the most exhaustive instruction in these systems. The seventeen essential parts of the Westinghouse system are enumerated and each part explained, point by point, the explanation being aided by diagrams, colored charts, and inserts. Examination questions with their answers form a large part of each volume, and the latest equipment is included in the course. The Air Brake Association and the highest individual authorities have combined to make the works complete and accurate to the finest detail. No one interested in air braking can afford to exclude these volumes from his working library.

FOUNDRY PRACTICE. A Text Book for Molders, Students and Apprentices. By R. H. Palmer. New York: John Wiley & Sons, 1912. 8vo.; 332 pp.; illustrated. Price, $2.

Starting with the simplest type of mold, the student is gradually made familiar with the more difficult operations in green and dry sand and loam. Cupola practice, mixing and melting, and the cleaning and repair of castings are all taught by the text. While the writer was instructor at the Worcester Polytechnic Institute, the need for an adequate instruction book was recognized by him, and the volume in hand presents in all its essentials the course he followed there. The learner will find much to help him along the road to practical efficiency.

WORM GEARING. No. 1, Machinery's Reference Series. 48 pp.; illustrated.

SHOP ARITHMETIC FOR THE MACHINIST. No. 18, Machinery's Reference Series. 48 pp.; illustrated.

LOCOMOTIVE DESIGN. No. 27, Machinery's Reference Series. Part 1—Boiler and Cylinders. 45 pp.; illustrated.

METAL SPINNING. No. 57, Machinery's Reference Series. 38 pp.; illustrated. Price, 25 cents each.

These are four of a long series of pamphlets published by the Industrial Press of New York city at twenty-five cents each, and aiming to cover exhaustively machine design and shop practice. They present in most cheap and convenient form the special information which mechanical engineers, master mechanics, designers, tool-makers and machinists must have. Wherever metal is worked some of these pamphlets might profitably be supplied.

DIARY OF A ROUNDHOUSE FOREMAN. By P. S. Reilly, late Associate Editor of the *Railway Review*. New York: The Norman W. Henley Publishing Company, 1912. 16mo.; 176 pp. Price, $1.

This is a series of articles written in narrative form, which originally appeared in the pages of the *Railway Review*. They contain a fund of information and suggestions along the line of handling men, organizing, and the like.

CONSUMPTION. Its Relation to Man and His Civilization. Its Prevention and Cure. By John Bessner Huber, A.M., M.D. Philadelphia: J. B. Lippincott Company. 8vo.; 536 pp.; illustrated.

The author's treatment of his important subject is broad rather than limitedly technical, popular rather than profound. Since pure medical science is too weak, unaided, to effectually cope with the problems of this disease, Dr. Huber seeks to show how the aid of economic, legislative, sociological, and humanitarian forces may be enlisted toward stamping out consumption, or at least in materially decreasing its ravages throughout the world. The avenues of infection are followed, and conditions of latency and immunity considered, with the factors of predisposition and environment. The prevention and cure of the disease is then taken up, and the remainder of the volume devoted to explanation and description of the various means employed for dealing effectually with the evil. The sanatoria of America and Europe are listed and illustrated, and their methods described. Measures governmental and otherwise are considered and urged, and a series of appendices contains technical matter that it has been deemed best to exclude from the main body of the work. Altogether the volume is worthy of wide distribution, dealing authoritatively and exhaustively, yet simply and forcibly, with the weapons which physician and layman may together wield in the fight against one of the greatest scourges of our modern civilization.

MODERNI SISTEMI DI RISCALDAMENTO EVENTILAZIONE. Ing. Angelo Izar. Milan, Italy: Ulrico Hoepli, 1912. 8vo.; 632 pp.; 250 cuts.

In a large volume of well-arranged material, Angelo Izar gives us a *résumé* of modern practice in heating and ventilation. Both sections of the work reduce the practice to figures and formulæ, and deal with their allied subjects from every point of view. The systems of heating include hot water, steam at low, medium and high pressures, and hot air. The numerous engravings add greatly to the attractiveness and utility of the work.

PRACTICAL PROBLEMS FOR VEHICLE DRAFTSMEN AND MECHANICS. R. B. Birge and Hugh M. Sargent. Philadelphia: Ware Brothers Company, 1912. Folio; 80 pp.; illustrated. Price, $2.

Workers in the vehicle trades will be greatly helped by the instruction imparted by Birge and Sargent. There are rules for laying out true sweeps or curves, and ovals; for laying out twisting or winding surfaces by the application of the proportional triangle; and for the practical solution of many other problems recurring in the trades. A system of perspective drawing for automobiles and carriages is illustrated and explained. There are hints on coloring drawings, and a set of working drafts for a torpedo roadster, a Colonial coupé, a limousine, a touring car, and other forms of carriage and automobile bodies. The large pages and calendered paper make the drawings very plain, practical, and satisfactory.

HISTORY OF THE ANCHOR LINE, 1852-1911. Glasgow: Printed by John Horn, Ltd. 140 pp. 50 half-tones and colored engravings. Size, 7x10 inches.

It must have been a labor of love which prompted the Anchor Line to bring out this really beautiful history of the operations of the line, which have extended over a period of about sixty years. Of the fifty or more engravings, the most valuable are a series of beautifully executed, 7-inch by 10-inch, four-color half-tone plates, printed on a black undertone, most of which are executed from paintings of the ships which have flown the Anchor Line flag.

The firm from which the Anchor Line has sprung was founded in 1838 by Messrs. Nicol and Robert Baird Handyside. The Henderson family, who have figured so largely in the management and control of the Anchor Line, included at this period four brothers, all of whom followed the sea and all of whom became captains of ships at an early age. Two of them began the business of marine engineers under the title of D. & W. Henderson, while the two other brothers, Thomas and John, at a later stage went into partnership as ship owners. In 1853 the Messrs. Handyside acquired a sailing vessel, called the "Tempest," of 844 tons register, which was commanded by John Henderson, and in her early history made one voyage to Bombay and also traded from the Clyde to Canada. In 1852 Mr. Thomas Henderson went into partnership with the Handysides, and the title "Anchor Line" was then adopted. In 1854 the Anchor Line built the "Vasco da Gama" for the Lisbon trade, and thus laid the foundations of the great Mediterranean business of the company.

From time to time new ships were added, and in addition to the trade which had been opened with Canada, the company in 1856 initiated the Glasgow-New York service, which in 1865 was established as a regular weekly service. It should be noted that to this company is due the credit of being first to take live cattle from the United States, an event which occurred in the year 1873. A notable accession to the line was their taking over the handsome and celebrated steamer, "The City of Rome," built for the Inman Line, a vessel of 8,453 tons and 560 feet in length. In 1882 a new direct Calcutta service was commenced. Notable among the later ships built to meet the ever-growing trade of the company were that handsome vessel, the "Columbia," the "Caledonia," the "California," and lastly, the "Cameronia," the last named being a vessel of 10,963 tons. In 1899 the enterprise was converted into a limited liability company, and the inclusion of the name of Henderson, which appears in the registered title, will serve to keep the memory of the founders to the front. The present service includes the Glasgow and New York trade, the Mediterranean and New York trade, the Bombay trade and the Calcutta trade. The company boasts of the fact that in its sixty years of life it has never received government subsidy of any kind, and both the old firm and the new company have always underwritten a large portion of their own risks. Altogether, the company have built or purchased 115 vessels, a total of 304,202 tons, the present tonnage of the fleet being about 130,000 tons. It was announced in the Glasgow *Herald* of November 28th of last year that an agreement had been concluded between the Cunard Steamship Company and Messrs. Henderson Brothers whereby the Cunard Company will acquire a large interest in the Anchor Line of steamships.

WE wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

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